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ABSTRACT

This newsletter contains items of interest to anyone concerned with science and society interactions. The first section of this issue contains 23 news and communication items including descriptions of academic and educational programs, conferences and seminars, and reports and opportunities that all relate to the social issues of science. Three feature articles are also included. The first is a request by the congressional office of technological assessment for input to the study of the health of the scientific and technological enterprise. The second article is a description of the nature, work, and future of the British Council for Science and Society. The third feature article is an essay dealing with the history of measures in science, science as a cultural mode, and measuring the health of science. The stated purpose of this essay is to hint of the complexities involved in any attempt to measure the health of science. A general bibliography is also included. (MR)

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NEWSLETTER
ON
SCIENCE, TECHNOLOGY & HUMAN VALUES

(Formerly: Newsletter of the Program on Public Conceptions of Science)

U S DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

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April 1977 Number 19

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Vivien B. Shelanski

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

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SE 022 868

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NEWSLETTER ON SCIENCE, TECHNOLOGY & HUMAN VALUES

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I. NEWS ITEMS AND COMMUNICATIONS

A. Public Service Science Residencies and Internships

The National Science Foundation has announced the establishment of an experimental program to encourage participation of experienced scientists and engineers, as well as students, in public service science activities.

As many as 25 Public Service Science Residencies for scientists and engineers and 25 Public Service Science Internships for students of science and engineering will be awarded by NSF on a competitive basis.

The focus of these public service science activities will be on providing citizens with the scientific information needed to help them make rational decisions affecting their daily lives, as well as on matters of public policy. Included could be such activities as research, preparing informational materials, and providing expert scientific and technical advice. Informal education activities -- seminars, lectures, workshops -- will also be considered.

Residents and Interns will work with host organizations that serve important public purposes, such as educational institutions, professional associations and societies, state and local government agencies, trade unions and associations, and citizens' organizations. They will not involve themselves in activities intended to advance already determined policy positions of individuals or organizations or to market particular products.

Public Service Science Residencies will be offered only to persons who already possess a doctorate in science, including engineering, mathematics, and the social sciences; will have one by the beginning of their tenure; or have acquired equivalent professional experience and qualifications. Tenure is normally twelve months of full-time participation. The stipend is $18,000 per annum, prorated at $1,500 a month.

Public Service Science Internships will be offered only to science majors who are enrolled in undergraduate and graduate-level science programs, including engineering, mathematics, and the social sciences. Applicants must have completed at least three years of undergraduate studies by the time they begin their internships. Tenure may range between six and twelve months. Full-time participation is required. The stipend is $5,000 per annum, prorated at approximately $420 a month.

Announcement and application forms are now available. The application deadline is May 15, 1977; the award date is September 15, 1977. For copies of the announcement and application materials, contact: the Office of Science and Society, National Science Foundation, Washington, D.C. 20550. Telephone 202-282-7770. Specify whether Public Service Science Residency or Public Service Science Internship.

B. Internship in Policy Related Science

The Margaret Mead Internship in Policy Related Science, awarded by the Scientists' Institute for Public Information (SIPI), is designed to develop undergraduate science students, through practical experience in the world of scientific work, as creative contributors to the community at large. Students work as interns for at least ten weeks at a time, either in SIPI's New York office or with one of the local committees, and many receive modest cost-of-living stipends and academic credit for their work. All undergraduate science students are eligible.

For further information and application forms, write to: Internship Director, SIPI, 49 E. 53 Street, New York, New York 10022.

C. AAAS R&D Budget Analysis Project: Second Annual Report and Colloquium

Following favorable response to last year's R&D in the Federal Budget report and its complementary colloquium, the AAAS Board of Directors has approved continuation of the project as an on-going annual activity of the Association. The project was initiated last year on a trial basis under the sponsorship of the Committee on Science and Public Policy, with the goal of improving understanding among the AAAS community of the federal budget and the budget processes as they relate to research and development.

Willis H. Shapley, who prepared R&D in the Federal Budget: FY 1977, will again be responsible for the 1978 analysis. The 1978 report will be an analytic summary and interpretive review of research and development in the annual budget, with objective analyses of some topics and issues of general interest.

Plans also have been made for a second colloquium in conjunction with the budget report. The meeting, which will provide a forum for constructive discussion of selected topics in the report by interested members of AAAS and officials of the executive and legislative branches of government, is scheduled for June 15-17, 1977. Topics for discussion will include future trends in R&D budgeting, the congressional role in R&D budgeting, and problems in the rationales and criteria for budget decisions.

Those interested in attending the colloquium are invited to contact: Catherine Lighthizer, Division of Public Sector Programs, AAAS, 1776 Massachusetts Avenue, N.W., Washington, D.C. 20036.

D. Workshops in Medical and Biological Ethics

The Institute of Society, Ethics and the Life Sciences will sponsor three workshops in the medical and biological ethics field this summer. One workshop, a survey of the field of medical ethics, is designed as an

intensive, issue-oriented introduction to medical ethics for those beginning to teach or do research in the field. A wide range of disciplines will be represented by both staff and participants.

The second "Workshop on Death, Dying and Public Policy" is designed for teachers, health care professionals, and those engaged in the formulation and execution of policies for the care of the dying.

The third workshop, on "Ethical Theory in a Medical Context," is designed for biologists, physicians, social scientists, and lawyers who have participated in previous workshops or had similar exposure to the issues, and who are now interested in a more systematic introduction to the philosophical ethical theory in a medical context.

The workshops are scheduled as follows: I and II will be held June 19-26, 1977 at Sarah Lawrence College, Bronxville, New York; the third workshop will be held June 26-July 2, 1977 at Stanford University, Stanford, California.

For further information, write to: WORKSHOPS, Institute of Society, Ethics and the Life Sciences; 360 Broadway, Hastings-on-Hudson, New York 10706.

E. Public Hearings on Institutional Review Boards

The National Commission for the Protection of Human Subjects will conduct public hearings on the performance of the Institutional Review Boards (IRBs) which review research involving human subjects. These hearings will provide an opportunity for investigators whose research proposals are reviewed by IRBs, members of IRBs, and other interested persons to address the Commission concerning difficulties that have been encountered under the existing system of review and suggestions for improvement.

The hearings on IRBs will be held at three locations:

April 5, 1977:	Room 204A Dirksen Federal Building 219 Dearborn Street Chicago, Illinois
April 15, 1977:	Room 15018 U.S. Court Federal Building 450 Golden Gate Avenue San Francisco, California
May 3, 1977:	Conference Room 6 Building 31 National Institutes of Health 9000 Rockville Pike Bethesda, Maryland

Each of these hearings will begin at 9:00 a.m. on the date noted and will be open to the public, subject to the limitation of available space. If warranted by the volume of requests to testify, hearings will also be scheduled for April 6 (Chicago), April 14 (San Francisco), and May 4 (Bethesda).

The hearings are planned to assist the Commission in identifying problems with the existing system, with regard both to shortcomings in the protection of human subjects and unnecessary impediments to the conduct of research. Suggestions for improvements either in the regulation or operation of IRBs are also solicited. Individuals presenting testimony are encouraged to focus on particular problems and suggestions.

Requests for further information should be directed to: The Public Information Officer, Room 125, Westwood Office Building, 5333 Westbard Avenue, Bethesda, Maryland 20016.

F. Inventory of Primary Source Material in Twentieth Century Physics

The Office for History of Science and Technology at the University of California, Berkeley, is undertaking a world-wide survey of archival holdings related to physics in this century. The published inventory which results will locate and identify correspondence and unpublished papers of approximately one thousand physicists active between 1900 and 1950. Of particular interest is documentation of contact between physicists and intellectuals outside the domain of academic physics.

Readers with special knowledge of:

--unpublished correspondence with physicists, particularly items in private hands or in archival collections associated primarily with non-physicists;

--letters to or from a physicist published in journals or books not likely to be well-known to historians of science;

--archival holdings of the papers of little-known physicists

are urged to relay this information to the Survey of Archives, c/o Office for History of Science and Technology, 470 Stephens Hall, University of California, Berkeley, California 94720.

G. Women Academic Scientists and Engineers Increase in 1976

The number of women employed full-time as scientists and engineers by universities and colleges reached 35,900 in January 1976. This was the second consecutive year that their numbers have increased by 5 percent. Men, still far outnumbering women, totalled 194,600 in 1976, but their rate of increase was only 2 percent in each of the last two years.

These and other findings were released in a Science Resources Studies Highlights by the National Science Foundation. The data resulted from NSF's 1976 Survey of Scientific and Engineering Personnel Employed at Universities and Colleges.

Despite the higher growth rate of women, there has been little change in their share of the full-time scientists and engineers total -- up from 15 percent to 16 percent between 1974 and 1976.

Copies of the Highlights, "Employment of Academic Scientists and Engineers Increases 3 Percent in 1976" (NSF 76-328), can be obtained upon request from the Division of Science Resources Studies, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550. Copies of the Detailed Statistical Tables (NSF 76-321) on NSF's 1976 Survey are also available upon request at the above address. An analytical report will follow in 1977.

H. Report on Scientific and Technical Communication

A recently released National Science Foundation report indicates that more scientists and engineers are writing about their work -- and the trend is expected to increase at least until 1980.

Scholarly scientific articles increased from 106,000 in 1960 to 151,000 in 1974 -- more than 40 percent -- and may increase to 169,000 in 1980. The greatest increase was in the field of environment, and the next greatest in computer sciences, indicating growing interest in those areas.

These and other trends in scientific and technical communications in the United States literature are described in a new report, Statistical Indicators of Scientific and Technical Communication, 1960-1980, Vol. 1, A Summary Report. The report, prepared by King Research, Inc. of Rockville, Maryland for NSF's Division of Science Information, represents the results of the first year of effort to develop a system of indicators of scientific and technical information.

Copies of the report are available from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 for $2.05. Stock number is 038-000-00295-3. A limited supply is available from the Division of Information, Economics of Information Program, NSF, Washington, D.C. 20550.

I. Conference Report: Toxic Substances and Trade Secrecy

"The definitive beginning of a long process." This assessment of the recent national conference on "Toxic Substances and Trade Secrecy" (TS-TS) was shared by many of its invited participants. "Toxic Substances and Trade Secrecy: A Forum to Investigate Rights and Responsibilities" was arranged and conducted by Technical Information Project (TIP) of Washington, D.C.,

and supported by the Ethics and Values in Science and Technology (EVIST) program of NSF. The four-and-a-half day gathering was held at Coolfont in Berkeley Springs, West Virginia, February 27 - March 3, 1977. It brought together forty leading workers from the U.S. and abroad in the toxic substances information area, representing a host of disciplines and affiliations ranging from academic ethicists to government medical scientists to corporate lawyers.

TS-TS marked the first time that adversaries have met in a formal session at the national level to develop criteria for the handling and dissemination of toxic substances information. The conference indicated that, while some basic agreement exists on the subject, a great deal of effort will be required to fully resolve questions of corporate rights to trade secrets vs. public rights to free information flow on toxic substances. Virtually all TS-TS participants agreed that absolute zero-risk is an unobtainable goal in toxic substances work, and an unrealistic one on which to base criteria. Keynote speaker Sheldon Samuels, director of the AFL-CIO's Health, Safety, and Environmental Affairs program, urged attendees to think in terms of "necessary risk." The thorny and ethically complex question of what constitutes risk, and how much information in regard to it should be given to the public brought out significant differences of opinion.

Four workshop groups within the conference spent considerable time developing white papers on rights and responsibilities of: scientists, producers, citizens, and government in handling toxic substances information. Included in these efforts were a "Citizens' Bill of Rights and Responsibilities" and a guide to research scientists considering "whistleblowing" actions in the toxic substances area.

Proceedings of "Toxic Substances and Trade Secrecy" will be available from Technical Information Project within about two months. TIP is a nonprofit research and education group based in Washington, D.C., specializing in environmental and resource conservation policy work. For more information contact: Dr. Arthur Purcell, Technical Information Project, #217, 1346 Connecticut Avenue, N.W., Washington, D.C. 20036. Telephone: 202-466-2954.

J. Lehigh University Newsletter Seeks Contributions

The Humanities Perspectives on Technology (HPT) Program at Lehigh University has announced plans for a newsletter to be published in the 1977-78 academic year. Funded by a grant from the National Endowment for the Humanities, the newsletter will cover a broad range of material in the area of technology, society, and human values. Its emphasis will be on courses and curriculum developments, particularly in the humanities.

Contributions about courses, workshops, and programs are invited and should be sent to: Dr. Stephen Cutcliffe, Humanities Perspectives on Technology, Maginnes Hall #9, Lehigh University, Bethlehem, Pennsylvania 18015.

K. SISCON Invites Subscribers

The SISCON (Science in a Social Context) Project, in an effort to enlist greater participation from individuals at institutions not currently represented, invites those interested to subscribe to the SISCON Newsletter. The subscription cost is $5.00 for individuals and $25 for institutions within the United States. Besides the Newsletter, subscribers will receive:

(1) notice of all new SISCON publications, (Institutional subscribers will also receive one free copy of each publication);

(2) reduced rates for attendance at SISCON organized conferences;

(3) the option of buying past and future SISCON publications at cost;

(4) access to support and expertise in the establishment and development of SISCON-type courses.

Subscribers will play an important part in the discussion leading up to the establishment of a SISCON Association on a more formal basis later. Checks should be made out to SISCON and sent to: SISCON Project, Department of Liberal Studies in Science, The University, Manchester M13 9PL, U.K.

L. Symposium: "Sociobiology: Implications for Human Studies"

The NEXA program of San Francisco State University will sponsor a symposium, "Sociobiology: Implications for Human Studies," on June 14 and 15, 1977. It will feature five panel discussions on the following themes:

--What is Sociobiology? -- the nature and future of sociobiology;

--Sociobiology: The Problem of Human Choice -- on the nature of moral and social choice in the context of genetic determinism;

--Sociobiology and Society -- on whether social, cultural, economic, and political structures are subject to biological explanations;

--Sociobiology: The Long View -- on sociobiology within the perspective of the history of ideas.

The Symposium is being held in conjunction with the meeting of the Pacific Division of the AAAS, but is open to the public without charge. All sessions will be held in McKenna Theatre, Creative Arts Building, San Francisco State University.

For further information, contact: Dr. Anita Silvers, Symposium Coordinator, School of Humanities, San Francisco State University, 1600 Holloway Avenue, San Francisco, California 94132.

M. Seminar: Public Policy Implications of Science and Technology

Robert H. Kargon, Professor of the History of Science at the Johns Hopkins University, will direct a June 6 - July 1 seminar at Johns Hopkins on the public policy implications of science and technology. The seminar will explore the evolution of science-society relationships, compare the American situation with other modernizing societies, and take up the general problem of the public administrator in a technically advanced nation.

The seminar is one of four humanities seminars for public administrators sponsored by the National Endowment for the Humanities. Further information about the seminar may be obtained from: Professor Robert H. Kargon, Department of History of Science, The Johns Hopkins University, Baltimore, Maryland 21218.

N. Conference: Dilemmas in Treatment

A five-day conference to explore dilemmas in psychotherapies and in contemporary medical practice will be held in Venice, Italy from July 24-29. For further information, write to: Clara Shapiro, Conference Coordinator, Center for Policy Research, 475 Riverside Drive, New York, New York 10027.

O. New Science and Environmental Writing Program at Lehigh University

A new undergraduate program in science and environmental writing is being offered by the Division of Journalism at Lehigh University in Bethlehem, Pennsylvania. The program consists of: (1) a major in journalism/science writing, (2) a minor in science writing, and (3) a concentration in environmental science writing offered jointly by the Division of Journalism and Lehigh's interdisciplinary Environmental Sciences and Resource Management (ESRM) program.

Planning for the overall program began two years ago when it was realized that with the increasing role of science and technology in today's society, there was a growing need for people who could understand and write about scientific and technological developments, particularly for the general public. The need was not only for journalists, but especially for scientists and engineers who could make their activities more comprehensible to laymen and thus gain greater public acceptance and support. Formal approval of the program -- which is oriented toward science and engineering as well as journalism students -- was granted in January 1977.

The journalism/science writing major is a combination of nine courses (28-32 hours) in basic journalism, science and environmental writing on the university newspaper, and requires at least 24 additional credits in science.

The 17-hour minor in science writing is for students who wish to major in another field but become skilled in science communication techniques. It consists of five science writing courses plus two semesters' work on the university newspaper.

The environmental science writing program provides a bachelor of sciences degree in ESRM with a concentration in environmental science writing. Students are required to take a core of 66 credits in preliminary science courses in biology, geology, chemistry, and physics, and 18 hours in the science writing program.

At present six courses are offered in the new program, including Basic and Advanced Science Writing; Politics of Science; Environment, the Public, and the Mass Media; Writing about the Environment; and Special Topics in Science Writing.

Anyone wishing further information should contact: Prof. Sharon M. Friedman, Science Writing Program Coordinator, Division of Journalism, University Center #29, Lehigh University, Bethlehem, Pennsylvania 18015.

P. Degree Program: Department of Technology and Human Affairs at Washington University

The Washington University Department of Technology and Human Affairs is offering M.S., M.A., and D.Sc. programs designed to educate individuals for careers in industry or public service at the interface of technology and society. The programs focus on the application of technology to contemporary societal problems, assessment of the impact of technology, and analysis of public policy issues that have technological components. Areas of concentration include energy, technology, and policy; environmental quality -- planning and policy analysis; renewable and nonrenewable resource technology, policy, and management; health-care policy analysis; application of communications technology to education and resource management; appropriate technology for international development; and technology assessment and technological innovation.

Students with undergraduate backgrounds in engineering, natural sciences, or mathematics generally apply to the M.S. and D.Sc. programs, while students with social science backgrounds enter the M.A. program.

Applications are welcome at any time. For further information, contact: Dr. Robert P. Morgan, Chairman, Department of Technology and Human Affairs, Box 1106, Washington University, St. Louis, Missouri 63130. Telephone: 314-863-0100, ext. 4506.

Q. Master of Science and Society Program at the University of New South Wales, Australia

The University of New South Wales has established a new course in the Faculty of Science leading to the award of the degree of Master of Science and Society (MScSoc). The course is designed for graduates in both the natural and social sciences who wish to learn more about current problems in the social relations of science and technology.

The course is offered at two levels: a pass degree awarded following two years of part-time study, and a third-year program of advanced study and research leading to the award of an honors degree for selected students.

For further information concerning course units offered in 1977, the form of application, and the conditions of enrolment, contact: Dr. J.R. Saunders, Science and Society Program Coordinator, School of History and Philosophy of Science, University of New South Wales, P.O. Box 1, Kensington, New South Wales 2033, Australia.

R. BSCS Sound-Slide Programs

The Biological Sciences Curriculum Study of the AAAS has developed two series of sound-slide programs that may be of interest to social studies and biology teachers. The first series, "Science and Mankind: The Social Implications of Scientific Theory and Discovery," comprises two packages: "An Inquiry into the Origin of Man: Science and Religion" and "The New Genetics: Rights and Responsibilities." The school price for each package is $114.50. Orders should be sent to: Science and Mankind, Inc., Box 930, Boulder, Colorado 80302.

The second series (also available as a 16-mm color-sound film) is entitled "Projections for the Future," and presents three models of alternative futures: growth, behavioral, and humanist models. The sound-slide packages for the growth model and the behavioral model each cost $75.00; the humanist model, $125.00. The 16-mm film versions may be rented for $20.00 each. To order, write to: Crystal Productions, Box 11480, Aspen, Colorado 81611.

S. AAAS Survey of EVIST Programs and Courses

The AAAS' Office of Science Education has initiated a survey of college level programs and courses (both academic and non-academic) in the field of ethics and values implications of science and technology (EVIST). The study, which is supported by a grant from NSF, is a follow-up to a similar study conducted a year ago at the Cornell University Program on Science, Technology, and Society.

The goal of the project is not only to provide access to information

about the increasing numbers of educational and research projects in the EVIST area, but also to facilitate communication between educational institutions that wish to develop new programs and persons involved in current programs. The survey will result in a directory of courses and programs in the EVIST area, to be published in the fall of 1977.

T. Directory of Resources in Science, Technology and Values

Ms. Kathryn Rucker of the Bishops' Committee for Human Values has compiled the 44-page Directory of Resources in Science, Technology and Values. The entries have been classified according to areas of interest, including major sections devoted to: Science, Technology and Society: General; Bioethics -- Health Sciences; Religion and Science/Medicine; Future Studies; Environment: General and Nuclear Energy.

Primarily intended to direct concerned individuals to organizations sharing their interests, the directory does not include college and university courses or degree program listings.

Copies may be obtained for $1.00 by writing to: Ms. Kathryn Rucker, Bishops' Committee for Human Values, National Conference of Catholic Bishops, 1312 Massachusetts Avenue, N.W., Washington, D.C. 20005.

U. Survey of Academic Technology and Society Activities

Addressed to faculty and administrators interested in the status and development of the science, technology, and society field, the Survey of Academic Technology and Society Activities focusses on programs concerned with technology and its impact on society. It provides information on the types and contents of programs (i.e., whether college courses, lectures, radio, or TV programs), the types of target audiences, and the types of institutions carrying them out. This survey is a publication of INPUT (Increasing Public Understanding of Technology), a program conducted by the Science and Public Affairs Office of The Pennsylvania State University and supported by the National Science Foundation.

This report is available upon request from: INPUT, 102 Materials Research Laboratory, The Pennsylvania State University, University Park, Pennsylvania 16802.

V. Ethics and Medicine Television Series

"Ethics and Medicine" is a television series dealing with contemporary moral and legal questions concerning health care. The eleven programs (sixty minutes each) in the series were produced at Bowling Green State University and Ohio Northern University with support from the Ohio Program

in the Humanities. The titles of the programs are: "Bio Medical Ethics: The Right to Live and the Right to Die"; "Bio Medical Ethics: Problems of the Allocation of Scarce Saving Therapy"; "Bio Medical Ethics: Is There a Right To Die?"; "Bio Medical Ethics: The Determination of Death"; "Bio Medical Ethics: Active Euthanasia"; "Conflicting Rights in Health Care: Accountability: Problems with PSRO's and the Right to Competent Care"; "Conflicting Rights in Health Care: The Patient's Right To Know the Truth"; "Conflicting Rights in Health Care: The Right Not To Be a Patient"; "Conflicting Rights in Health Care: Some Problems of Distributive Justice"; "Conflicting Rights in Health Care: The Right of Reproduction"; "Conflicting Rights in Health Care: Decisions Concerning Rights to Life or Death."

The Programs are available on videocassette (3/4" U-matic) color for seven-day rental, free of charge, from: The Ohio Program in the Humanities, 628 College Avenue, Columbus, Ohio 43209; telephone: 614-236-6879.

The Programs may be purchased on 3/4" videocassette for $65.00 each, or $650.00 for the entire series of eleven programs, from: WBGU-TV, Bowling Green State University, Bowling Green, Ohio 43403; telephone: 419-372-0121.

CORRECTION:

Science, Technology, and Society: A Guide to the Field; Directory of Teaching, Research, and Resources in the U.S., E.D. Heitowit, J. Epstein, and G. Steinberg (eds.), is available free from the Cornell University STS Program while a limited supply lasts (one copy per program, department, research group, etc.). Send requests to: Program on Science, Technology, and Society; 620 Clark Hall; Cornell University; Ithaca, New York 14853.

Additional copies can be ordered from: The National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161. When ordering, please indicate the NTIS Accession Number: PB 262 487/AS; price: $13.50.

II. REQUEST FOR INPUT: OTA STUDY OF THE HEALTH OF THE SCIENTIFIC AND TECHNOLOGICAL ENTERPRISE

By Harvey Brooks
Benjamin Peirce Professor of Technology and Public Policy
Harvard University
Cambridge, Massachusetts 02138

The Congressional Office of Technology Assessment (OTA) has initiated a long range program on R&D Policies and Priorities. Three separate advisory panels have been established, with their work to be coordinated through OTA's statutory Technology Assessment Advisory Council (TAAC), which is chaired by Jerome Wiesner of MIT. The three panels are to deal respectively with: the Health of the Scientific and Technological Enterprise; the Applications of Science and Technology including industrial research and innovation; and the Decision-Making Processes whereby the nation sets its policies and priorities with respect to the allocation of R&D resources and the utilization of scientific inputs in government policy generally.

The Panel on the Health of the Scientific and Technological Enterprise, which I chair, would like suggestions from the technical community and from other interested and concerned publics. It is particularly interested in receiving views as to: what issues should be given priority in its agenda; what are some of the perceived problems and strengths of the present system of overall management and support of research and development in the United States; and how the future system might look. The purview of the Panel includes but is not restricted to basic research in universities and the system of advanced education in the natural and social sciences. The Panel has adopted a provisional working definition of "health": "the capacity of the U.S. science and technology enterprise to develop new knowledge and insights both for their own intrinsic values and for the contribution they can and should make to the solution of some of the major problems which face mankind and the nation." However, the Panel would welcome suggestions for a better definition.

Currently the Panel is engaged in defining the scope of its work and setting priorities for its study agenda. Some of the issues that may be considered include the following:

--The development of objective criteria for assessing the health and performance of the science and technology enterprise, including its ability to maintain its capacity into the future;

--The validity of current national R&D priorities including priorities in fundamental science, taking into account both future social needs and probable scientific and technological opportunities. The issue involves the development of more systematic criteria for assessing scientific and technological priorities.

--The functioning of the overall research enterprise as viewed from the perspective of the working scientist: whether he is working on the problems that he considers most important and interesting, whether he has the freedom and opportunity to use his maximum capacities and training, how he views his relationship to society and to social priorities.

--The proper balance between scientific freedom of the investigator and the professional obligations of the scientist for the consequences of his work and for communication with the public and with decision-makers in industry and government.

--The responsibilities and rights of scientists when their obligations to their employer and to the broader society appear to come in conflict.

--The proper relationship between research and higher education; the degree to which research should play a role in universities and which aspects of research needed by society would best be conducted by non-academic institutions, private or governmental, specifically configured toward meeting certain social needs and special scientific or technological opportunities.

--What alternatives might and should exist to the present traditional basic research and teaching careers for scientists and engineers who are trained to the Ph.D. level primarily through research apprenticeship.

--The nature and existence of a "critical mass" effect in various disciplines and fields of research, and whether the present national research effort in various fields is too concentrated or too dispersed for optimal use of available resources.

--The future role and form of broad-purpose national laboratories, and the specific requirements for a healthy and socially useful national laboratory system, including relationships with universities and industry.

--Whether the present system of graduate and postdoctoral training tends to produce too many people trained in currently fashionable fields to the neglect of other fields of greater potential intrinsic interest or social importance, or whether the adaptability of highly trained people combined with "market" forces in the broad sense will remain sufficient to insure a reasonably optimal allocation of technical manpower in the long run.

--The proper allocation of government support among: specific project grants to individual investigators, general research support to institutions, and support for individual scientists on the basis of promise and accomplishment with review of performance largely after the fact.

--The equity of access to the career opportunities provided by the scientific and technological system on the basis of capacity to contribute.

--The impact of trends in the movement of scientists and engineers between the U.S. and foreign countries, both developed and developing, and what steps if any should be taken by the national government to influence such trends.

Communications and suggestions from persons in the technical community or from the general public concerned with the health and impact of science and technology would be welcomed by the Panel. Such communications should be addressed to Harvey Brooks, Chairman, OTA Panel on the Health of the Scientific and Technological Enterprise, Aiken Computation Laboratory 226, Harvard University, Cambridge, Massachusetts 02138.

III. THE BRITISH COUNCIL FOR SCIENCE & SOCIETY

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Introduction

The Council for Science and Society, operating in London since 1973, provides an interesting example of differences in style in this field between the U.S.A. and the U.K. It consists of some three dozen people eminent in science, academia, or public affairs. They supervise the work of a small office that organizes study groups, and they then review and sponsor the published reports. The Council is self-appointed, independent of government and industry, and funded by private charitable foundations. Its reports are directed at decision-makers in the first place, though it is hoped that students in particular areas, and the general public, will also read the reports and be influenced by them. So far the Council has approved three reports. Two of them, "Superstar Technologies" and "Scholarly Freedoms and Human Rights" are already published, while the third, "Acceptable Risks," is expected to be published in May 1977. Several other reports are on the point of completion.[1]

Origins

The Council's origins lie in the same sense of unease about ethical and policy problems of science that produced the discussions and demonstrations in America in the late 1960s. In Britain the concern first showed itself in the creation of the "British Society for Social Responsibility in Science." The B.S.S.R.S. quickly found a job to do in investigating the accusations of science-based brutality by the British military in Northern Ireland, both the torture of detainees and the use of C.S. riot control gas in the disturbances in Derry/Londonderry. It soon settled down to a radical position, rather like Science for the People in the U.S.A. Within the "establishment," the British Association for the Advancement of Science was being reorganized and rejuvenated. Although "social" concerns at its Annual Meeting were still generally relegated to the "miscellaneous" Section X, it did sponsor some very useful studies on "science and society" problems. The august Royal Society makes an annual grant to the British Association, and has considered that to be the full discharge of its responsibilities to general social concerns.

This absence of official concern is in strong contrast to the situation in the U.S.A., where such agencies as the Environmental Protection Agency and the Office of Technology Assessment, and special study groups organized by the American Association for the Advancement of Science and the National Academy of Sciences (in particular, the latter's Committee on Science and Public Policy) have been bringing issues of the social impact of science to public notice for some years. In England, by contrast, the initiation of such work was left to isolated individuals operating in a somewhat amateurish style.

It was a non-scientist who first tried to create a "science and society" organization that would be lively and yet respectable. This was Paul Sieghart, one of the Viennese Britons who are now playing a very important part in the nation's intellectual life. Having achieved his ambition of retiring from the Bar before the age of 40, he devotes himself to various good causes, and is currently the leading U.K. expert on the problems of computers and privacy.

Sieghart tried, on both the "established" and "anti-established" sides, to rouse interest in a study of the "science and society" problem that would be committed and yet non-partisan. Finding little response in either quarter, he went ahead on his own in 1970 and convened a study group of scientists and laypersons. They concentrated on the ethical problems of the scientist who makes a discovery that is capable of application for good or evil. Seeing that the problem cannot be solved on an individualistic basis, the group recommended the establishment of a Council of eminent scientists to whom such worried researchers could turn. The Council could first check out the technical side of a scientist's claims, and then advise society of the likely impacts, offering suggestions for coping with these according to possible societal value-choices.

The report embodying this analysis and suggestion circulated among eminent people for a while, and was published in Nature late in 1972.[1] Shortly afterwards, about a dozen scientists formed the Council. The Chairman was Sir Michael Swann, just then leaving the Vice-Chancellorship of Edinburgh University to become Chairman of the Governors of the B.B.C. Sieghart himself was Vice-Chairman. The Council soon enlarged itself to its present size (approximately 45 members), trying to secure a balanced representation among fields of expertise and among special interests in its areas of concern. When, later in 1973, the Leverhulme Trust awarded a generous grant to the Council, I was appointed Executive Secretary on a part-time basis.*

The Council's Work

Although the Council's existence was publicly announced, we did not receive requests from worried scientists as anticipated in the initial study. We therefore invented our own topics, rather more general but nonetheless provocative for that. Their short titles are: "Acceptable Risks," "Behaviour Control," "Harmless Weapons," "Information Overload," "Soma," and "Superstar Technologies." We fairly soon discovered the price to be paid for producing high-quality reports in this genre: unremitting hard work with ideas and with people, and the strong chance of the collapse (social and intellectual) of any project. The easier topics were the "trans-disciplinary" ones, lacking in any comprehensive and recognized expertise. There all we had to contend with was an initial confusion. But where an established field was being scrutinized (particularly one involving a profession rather than a mere subject-specialty), people with institutional reponsibilities were very reluctant to give public endorsement to outsiders' criticisms of their basic assumptions.

The composition of the study groups was therefore quite crucial. They were to consist of unpaid volunteers, with an "uncle" representing the Council. The office staff was to provide administrative assistance and to organize research work where necessary. The reports were, ideally, to combine the rigorous argument and evidence of the scholar with the clarity of writing of the popularizer

and the relevance and practicality of the decision-maker. Such criteria were challenging indeed, particularly for groups of people who frequently had little previous familiarity with each other or the topic.

There are not many rules for this sort of work. Success depends on experience and personal contacts; and at the beginning we were not well-endowed with either. It is not surprising that a goodly proportion of the projects floundered or slowed down to a state of suspended animation. Those on the control and modification of human behavior were worst afflicted with difficulties, perhaps because of the relative weakness of the staff in those areas, combined with the tighter professional structure. More significant is our discovery that this approach can sometimes work. And when it does, it is very exciting and rewarding. I can give two examples of how success can come, very different in character but thereby showing the variety of the work.

The "Scholarly Freedoms" Report

Professor John Ziman, F.R.S., and Paul Sieghart have served as co-directors of the "Scholarly Freedoms" project. Ziman, the present chairman of the Council, is a well-known campaigner for scientists' civil rights. His most publicized work has focussed on Soviet physicists who have been deprived of their jobs and status as punishment for any sort of political deviance. He and his colleagues in this work have appealed to the conscience of scientific and public opinion, both in the offending nations and internationally. Paul Sieghart has long been concerned with the legal aspects of human rights, and has helped in framing international conventions guaranteeing such rights. Many such conventions are signed and ratified by most members of the United Nations, and so have some degree of legal force both internally and internationally.

The Council convened a Working Party with these two individuals and several eminent scientists known to have a concern for the problem. The task was to relate the scientific side (arguing why scientists require certain freedoms if they are to do their jobs properly) and the human rights side (showing which freedoms are recognized and guaranteed). Although two different sorts of "paradigms" were involved, the thinking and drafting could be done in a relatively brief span of intensive work.

A surprisingly simple and inexpensive, practical proposal is made in the Report which resulted from their efforts: that there be a small office which collects and transmits information, both on the changing legal situation and on individual cases. The existence of such an office will certainly help the position of oppressed scientists; and it will thereby contribute to the cause of scholarly and intellectual freedoms everywhere.

The "Acceptability of Risk" Report

Another successful project, that on risks, forms an interesting contrast. Here we had no clear guidance on the problem, though we could gain insights from the Council's previous report on "Superstar Technologies" (largely the work of John Ziman) and from the recently published American book, Of Acceptable Risk, by W. Lowrance, a pioneering empirical survey of the problem.[3] Our Working Party was strong, with several members experienced in one end or another of the "hazards" business. It did not take too long for the shape of the report

to emerge: successive discussions of the conceptual and quantitative aspects of risks, the problems of calculating costs and benefits in this context, and then the ethical and practical questions of "fair decisions and effective controls." All this was to be expressed in a readable style within the span of some twenty thousand words.

We tried some empirical studies conducted by temporary researchers, but it became clear that we needed to solve our conceptual problems before we could instruct an assistant. This clarification was arduous; not a few of my drafts were rejected by the Working Party as "incomprehensible" or "turgid." And, in retrospect, they were; I was trying to say everything of possible relevance until I understood the problem well enough to know what could be omitted. The main controversy in the Working Party was over quantitative methods. We found ourselves in the crossfire of a long-standing feud between two rival regulatory agencies -- the U.K. Atomic Energy Agency, committed to the use of quantitative methods of risk assessment, and the Nuclear Installations Inspectorate, relying more on intuitive engineering skills for monitoring plants in construction and operation. This conflict imposed an extra discipline on my remarks about quantification: they had to have sufficient content for inclusion and yet gain a consensus of sharply divided members.

As the months wore on and we worked through drafts covering more of the original outline, we found ourselves in an uncomfortable situation: most of our conclusions were negative! Quantification of probabilities is not precise; and quantification of costs and benefits is highly imprecise. The varieties of "acceptability" of risks (involving individuals' special perceptions, values, and available options) limit the analytical use of the concept. The dilemma between the individual's right to accept or reject the danger that is thrust upon him, and the society's need to impose some risks for general benefit, seemed insoluble.

Very intensive sessions with Working Party members and outside consultants indicated approaches to a solution. One was an adaptation of some insights of Rawls,[4] recently developed very effectively by Laurence Tribe,[5] that fairness lies not only in the substance but also in the procedure of decisions. We used this concept in the context of the "social dynamic" of a hazard between the three sides who (respectively) create, endure, and regulate it, and who each have their perceptions, values, and powers in the situation. We explained how these "subjective" aspects of the problem pervade all the others, right down to the collection of data.

In our conclusions we shifted the focus from "acceptability" of risks to "fair decisions and effective controls." We stressed that "objective" scientific methods, while necessary for a competent study, are not sufficient for a proper decision on behalf of society. Following Tribe, we saw decision-making on risks not as a static, once-for-all choice, but rather as a dynamic process, involving continuing education for all sides. Our main practical recommendation was for a pilot program of "community risk advisory centers," analogous to other volunteer-organized local service activities. Such centers would also provide a strong and direct social relevance for some sorts of scientific expertise.

The Future

The first three years of the Council's existence (now stretched to four by a generous supplementary grant) have been a period of learning, mainly from our many mistakes but also from successes of the sort I have described here. Barring catastrophes, we should have a half dozen reports published before the end of 1977. We are far from ready to "go public" in any way, so our continued existence will depend on the good will and trust of small groups of people in the foundations that support such ventures. We feel guardedly optimistic, if for no other reason than that the problems are there, indeed in increasing number, and no one else in Britain has yet stepped forward to study them at the Council's level, in the Council's special style.

NOTES

1. "Scholarly Freedoms and Human Rights" was published in February 1977, "Superstar Technologies" in 1976, by Barry Rose Ltd., Chichester, West Sussex, U.K. "Acceptable Risks" is expected to be published in May 1977. The reports are available from the publisher for $5.00 postpaid.

2. Paul Sieghart, "A Corporate Conscience for the Scientific Community?" Nature 239 (1 September 1972): 15-18.

3. William Lowrance, Of Acceptable Risk: Science and the Determination of Safety (1 First St., Los Altos, California: William Kaufmann, Inc., 1976).

4. John Rawls, A Theory of Justice (Cambridge, Massachusetts: Harvard University Press, 1971).

5. Laurence Tribe, C.S. Schelling, and J. Voss, eds., When Values Conflict (Cambridge, Massachusetts: Ballinger, 1976).

* Leverhulme Trust has made a second grant to the Council which will enable it to carry on for another three years. The new Executive Secretary is Sir Ieuan Maddock, F.R.S., who is joining the Council upon his retirement as Chief Scientist at the Department of Industry.

IV. REFLECTIONS ON THE MEASUREMENT OF SCIENCE

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Introduction

Measure is a quality much-admired in the abstract. The Horation dictum -- that "there is measure in all things" -- knows its greatest successes in the field of natural science. Even there the adoption of quantitative modes has not been especially rapid, complete, or devoid of controversy. Nonetheless, measurement has come to be perceived as central to the character and critical for the success of the scientific enterprise.[1] Science and society being of a piece, it should occasion no surprise that attempts to extend a metric from the natural to the social sphere and even to measure science itself have a rich, complex, and variegated history. That history has recently been moved to a new level and taken on fresh saliency as a result of actions by the National Science Board. The Board has committed itself to what, in its own words, is the ambitious task of developing "a set of indices which would reveal the strengths and weaknesses of U.S. science and technology, in terms of the capacity and performance of the enterprise in contributing to national objectives."[2]

Science Indicators 1972, Science Indicators 1974, and the soon-to-be-released Science Indicators 1976 are the first steps toward this stated goal. As such they merit, and are already receiving, extensive analysis and scrutiny.[3] SI-72 and its successors may, however, be viewed not so much as technical reports but as cultural documents, imperfectly embedded in certain historical traditions and raising interesting, perhaps insoluble intellectual problems.

In keeping with this rather different perspective, I wish to sketch the historical development of attempts to measure certain aspects of the sciences. I shall go on to point out that science itself may be viewed in more than one way and that what is measured depends on what is seen (and thus -- but more indirectly -- on what is looked at). Lastly, I want to illustrate the sort

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I gratefully acknowledge the stimulus of discussions with Robert K. Merton (Columbia University), Steven Shapin (Edinburgh University), Edward Shils (University of Chicago), and with colleagues on the Subcommittee on Science Indicators of the SSRC Committee on Social Indicators, and at the University of Pennsylvania. I am indebted to the National Science Foundation for partial support of this research. Several of the themes touched on in the opening section in this essay are more fully developed in: Yehuda Elkana, Joshua Lederberg, Robert K. Merton, Arnold Thackray, and Harriet Zuckerman, eds., Toward a Metric of Science: Essays Occasioned by the Advent of Science Indicators (New York: Wiley Interscience, publication expected in fall 1977).

of problems that arise from such differences in vision and focus. I shall do this by examining some of the arguments used in the most famous public debate ever staged about the health of science. My aim is a fuller appreciation of the complexities of past circumstance and the ambiguities inherent in any attempt to measure knowledge. Such an appreciation may help foster an appropriately cautious, sober, and modest commitment to the development of science indicators.

The History of Measures of Science

The history of attempts to measure science is long but fragmentary.[4] The most salient observation is how isolated from one another were previous workers seeking to quantify changes in aspects of science. Their work was rarely cumulative. It lay in different traditions, focussed on different questions, proceeded on different assumptions, answered different needs, and showed little communication between disciplines and countries. Even so, it is possible to discern some pattern and coherence, and to distinguish between five genres in which work has taken place.

The most interesting of these genres, but the least developed with respect to science, is that of civilizational history. Logically, the line of development should begin with Condorcet and dwell on Auguste Comte. However, it was Henry Buckle who was to be most heavily cited in subsequent works. The spirit pervading his classic account of the scientific life of Scotland -- the wish to "accomplish for the history of man something equivalent...to what has been effected by other enquirers for the different branches of the natural sciences"[5] -- pointed toward a comparative, classifying, and measuring approach to intellectual activity. The same desire for a historically-based science of man may be seen in works by authors as varied as John Theodore Merz, Edward Eggleston, and Pitirim A. Sorokin.[6] Each shared the belief that high intellectual achievement, and with it scientific thought, could be objectively assayed. However, the chief importance of civilizational history lay not in its implicit thrust toward assessing the quantity and caliber of pure knowledge in various countries and periods, but rather in its indirect stimulus to the sociology of progress, genius studies, and statistical bibliography.

The sociology of progress -- in various ways an obverse, complementary field to civilizational history -- may be seen as the primary stock from which the present burgeoning field of the sociology of science has developed. The path runs from Auguste Comte and Herbert Spencer to Lester Ward and William Ogburn in the U.S.A. Ogburn -- later to be honored as the first President of the Society for the History of Technology (1959) -- worked with the twin convictions that "science will grow in the social studies in direct ratio to the use of measurement" and that "any investigation of motives is likely to be superficial without the recognition of cultural factors, which can be discerned only through historical investigation."[7] These convictions helped inform the creative synthesis achieved by Robert K. Merton in his 1938 study of Science, Technology and Society in Seventeenth Century England. In that work, Merton investigated how a cultural factor (Puritanism) affected individual motivation toward science. He also brought measurement to bear in the provision of economic and technological answers to the question of why certain sciences flourished in particular cultural contexts.

Despite the work of Ogburn and the young Merton, the trends around which sociology of science coalesced as a field in the quarter-century after World War II were not those of science in society, of cultural dimensions, material needs, and broad historical patterns. As with other areas of American sociology, interest moved instead toward the micro-analysis of the internal dynamics of small institutions. This move fitted well with developments in American science itself. As research budgets grew, publications mushroomed and Ph.D.s proliferated, questions of organization, procedure, and reward within the burgeoning ranks of American, academic science enjoyed a new saliency.[8]

The sociology of science now provides us with many measures of contemporary scientific activity and its internal organization, but few indices of the intellectual character, social supports, cultural orientation, or historical development of scientific knowledge. The same may be said of the genre of statistical bibliography. The pioneering investigations of F.J. Cole, Nellie B. Eames, and E.W. Hulme in the years around 1920 did have a direct interest in historical and cultural patterns, as is obvious from the titles of their studies.[9] However, the forms of systematic, quantitative analysis of scientific literature that have developed since World War II have been -- perhaps necessarily -- preoccupied with questions of production, control, distribution, and consumption rather than those of cognitive content or cultural meaning.[10]

The above remarks may serve to indicate how the history of certain aspects of the measurement of science has been formed around agendas focussed on quite disparate questions. Science as high intellectual achievement implies measures quite different from those appropriate to science as the expression of certain motivations or as an autonomous social system. The point is persuasively brought home by attention to the two remaining genres. Genius studies and policy-oriented lobbying for science both have a venerable history, a voluminous literature, and their own quite distinct agendas.

The Swiss botanist Alphonse de Candolle seems to have been among the first to carry out a systematic numerical investigation of scientific genius. His 1873 Histoire des Sciences et des Savants Depuis Deux Siècles (Geneva) was stimulated by the social statistical school of Quetelet, of whom he wrote admiringly. He sought to establish the significance of environmental factors in nurturing scientific genius and, consequently, scientific progress. He was quickly embroiled in controversy with Francis Galton, the founder of biostatistics, who wished to emphasize the importance of heredity. Galton's English Men of Science (London, 1874) was followed a generation later by Havelock Ellis's Study of British Genius (London, 1904). In the United States, James McKeen Cattell (a one-time pupil of Galton) was important in establishing the quantitative study of genius -- work which came to involve figures as varied as Ellsworth Huntington, Scott Nearing, Frederick Woods, George Sarton, and Stephen Visher.[11] In this genre outstanding men were at the focus. Their actual intellectual products and the organizational contexts of their work were matters of secondary concern.

Policy-oriented lobbying for science is a genre organized around use rather than particular intellectual form. Arguments within this genre have an international and comparative aspect. The case for attention to a particular

science has hinged on contrasts with the (more favorable) situation in other nations or disciplines. The appeal may be to national pride or to economic self-interest. It usually involves measures of some of: the money committed to buildings, equipment, and salaries; the scale of educational arrangements; the opportunities open to career scientists; the publication of research results; the public esteem bestowed on scientific work; the patents, innovations, and economic progress believed to flow from science. In Britain, these recurrent motifs may be traced from Charles Babbage and his 1830 Reflections Upon the Decline of Science in England through the 1870s "Devonshire" Royal Commission on Scientific Instruction and the Advancement of Science to the influence of Marxist thought on a remarkable group of young scientists in the Depression. Julian Huxley's Scientific Research and Social Needs (London, 1934) and J.D. Bernal's pioneering study of The Social Function of Science (London, 1939) paved the way for those systematic efforts to measure science which have characterized government action over the last generation. For America, the corresponding history would have to run from Alexander Dallas Bache (great-grandson of Benjamin Franklin) and Henry Rowland through George Ellery Hale and R.A. Millikan to that gem of the lobbyist's art, Vannevar Bush's Science: The Endless Frontier (Washington, D.C., 1945).

By the early 1950s there was a great boom in governmental measuring of aspects of science in all Western countries. The growing number of international reports led to methodological and bibliographic studies of science statistics. From 1966 UNESCO published an Annotated Accessions List of Studies and Reports in the Field of Science Statistics. In 1969 Christopher Freeman published a methodological investigation of science indicators.[12] The culmination of this phase and the beginning of a new era may both be seen in the publication of the most ambitious study up to that date, the National Science Board's Science Indicators 1972.

Science as a Cultural Mode

In practice, powerful traditions in the scientific community foster a view of science which sees it primarily in terms of results rather than processes -- whether those results be held to reside in theories, hypotheses, laws, or established facts. In this view, science possesses very great internal autonomy. Interaction with the larger society takes place primarily (a) through decisions whether and on what scale to fund the necessarily esoteric, specialized needs of the practitioners of research, and (b) through intellectual and societal impacts of the "results" of that research. Such a view of science is implicit in much of the analysis in Science Indicators 1972 and its successors. The emphasis is on aggregates and on "input-output" models; the focus is on consumption of financial resources and production of people, papers, and patents.

Other traditions, however, suggest that it may be analytically more fruitful to view science as a mode of culture, and hence of cognition, education, socialization, and control. The work of Mary Douglas suggests the possibility of constructing a typology which systematically relates social structure to varieties of cosmology. Her work also suggests ways of understanding how cosmology changes as social structure changes.[13] For example, it may be that preferred modes of science in an industrial society will be found to be physics and chemistry. In an agrarian society the favored modes may be geology, natur-

al history, and meteorology, while in a "post-industrial" service economy the social and biological (medical) sciences will be preferred. The argued or perceived "utility" of each of these modes is part of the cultural constellation in question.

This means that if we wish to develop indicators of the "health" of science, we shall have to attend at least in part to the sociology of knowledge. What changes are taking place in our own social system? Which of these changes carry implications for science as a mode of culture? To answer such questions much greater stress must be placed on understanding public attitudes to science, on seeing how "images" of science in different social and professional groups relate to other aspects of their cultural experience, and on comprehending the manner of socialization in the ways of science which these varied groups receive via formal education and informal popularization.

The difficulties inherent in the search for consensible indicators of the health of science are apparent if we look at the discrepancies between contemporary analyses of the state of science in the past and what we now know from hindsight. Many examples spring to mind. Henry Rowland deplored the poor state of American physics, just as it was inexorably moving to a new maturity. French scientists of the later-nineteenth century castigated their countrymen for their parsimoniousness even as French chemistry waxed stronger and stronger. American science-watchers solemnly discussed American indifference to basic research as the country embarked on an unprecedented funding of pure science. Most notorious of all, Charles Babbage and a cohort of cooperators lambasted The Decline of Science in England at a time when English science was newly-launched on a wave of intellectual and organizational creativity.[14]

The extended debate in the 1830s over The Decline of Science in England illustrates with particular clarity the significance of differences in focus and vision.

Measuring the "Health" of Science: An Example

All parties to the dispute over the state of English science shared one fixed reference point. It was that the country of Sir Isaac Newton could claim no continuing tradition of mathematical astronomy or theoretical physics remotely able to challenge the French school of Maupertuis, Lagrange, and Laplace. To some this one fact about one field was sufficient evidence of a decline in English science. To others it became so, but only in the context of events.

Among those events were several of particular relevance. One was the 1828 decision of the British Government to abolish the Board of Longitude, thus decreasing dramatically the supply of patronage available to London's growing scientific corps. Of separate but equal emotional significance was the loss of three of London's leading men of science. All were to be eponymized in science. All had enjoyed high office in, and two had been President of, the Royal Society. When Sir Humphry Davy, Thomas Young, and William Hyde Wollaston died within a six-month period (December 1828 - May 1829), the shock was correspondingly severe. Quite different and far less dramatic, but also important, was the unrest of the scientific corps over the state of English patent law. The intimate links that then existed between the personnel of science and the world

of the inventor meant that many men of science were acutely aware of the disappointing financial rewards held to result from the Government's indifference to innovative genius.

It took just such an innovative genius, the irascible Charles Babbage, to forge from these elements a sustained debate, a reformist lobby, and a first attempt to measure the health of science. Babbage was the (absentee) Lucasian professor of mathematics at Cambridge, the struggling if state-financed inventor of the "difference engine" (a mechanical digital computer), the well-connected confidante of men of science and of men of affairs, and the impatient visionary of a new, better world. His 1830 Reflections on the Decline of Science in England perfectly expressed the grievances of one in his position. That it did far more is apparent from the flood of agreement, disagreement, congratulation, and criticism its publication unloosed.[15]

The European debate that ensued about "The Decline of Science in England" provides a generously documented example of a social context in which the health of science became an issue. The arguments of the various protagonists in the debate reveal much about the sorts of implicit and explicit indicators to which different groups are likely to appeal in such circumstances. Here it must suffice to concentrate on the alternative visions offered by Babbage and his main combatant (Gerard Moll, an Anglophile Dutch professor), the implicit indicators to which the pair appealed, and the sober benefits of historical hindsight.

To Babbage, the fact of "decline" needed no proof: "that science has long been neglected and declining in England is an opinion...shared by many, and has been expressed by higher authority than mine." The authority in question was J.F.W. Herschel, who had written that

> here, whole branches of Continental discovery are unstudied, and indeed almost unknown, even by name. It is in vain to conceal the melancholy truth. We are fast dropping behind. In mathematics we have long since drawn the rein, and given over a hopeless race. In chemistry the case is not much better....There are, indeed, few sciences which would not furnish matter for similar remark.[16]

Babbage agreed with Herschel that decline in English science was obvious, that failure to dominate the research front was the essence of decline, and that failure to be cited in or to cite appropriate foreign literature was its implicit indicator. Babbage went on to spell out what he saw as the causes of decline.

Firstly, "some portion of the neglect of science in England, may be attributed to the system of education we pursue." That system did not contain sufficient incentives (compulsory examinations) to the study of chemistry, botany, geology, history, etc., with the result that "scientific knowledge scarcely exists among the higher classes of society." Thus if inadequate foreign citation was the implicit indicator of decline itself, inadequate socialization into science of the country's elite was the first of its causes. The second set of causes related to the rewards of science, in prestige, organizational, and monetary terms. Here it was important to realize the peculiar advantages arising from the "classification of society into professions." But,

alas, "the pursuit of science does not, in England, constitute a distinct profession, as it does in many other countries. It is therefore, on that ground alone, deprived of many...advantages."[17] In particular, science lacked clear career paths, well-rewarded positions, and the public respect that followed regulation from within by self-selecting professionals.

It was in discussing science as profession that Babbage appealed most explicitly to statistical indicators -- tabulating foreign scientists who held public office (high numbers being good), the fraction of national populations admitted to national scientific societies (higher fractions being bad, indicating lax and unprofessional standards), the fraction of academy members holding honorific decorations (the names of Laplace, Lagrange, Berthollet, and Chaptal indicating high honor to science in France), and the monetary incomes of men of science (high incomes being good, showing that "the laborer is worthy of his hire"). Each and every one of these measures revealed the unsatisfactory situation of English compared with Continental science (the idea of using the United States for comparison was so absurd as to require no discussion). Together with the failings in the educational system, these implicit indicators helped explain "the gradual decline of mathematical, and with it of the highest departments of physical science, from the days of Newton."[18]

In stark contrast to Babbage, Gerard Moll would not admit the Alleged Decline of Science in England. Its indicators were either mistakes or misleading. British work was eagerly read on the Continent: the failure of the English to cite (not be informed about) the work of foreigners revealed not the incompetence of English science but the linguistic chauvinism of England. Indifference to science among the aristocracy was true of all countries. Honorific decorations and high monetary incomes to men of science merely indicated corruption, flattery, and diversion of talent from scientific to political ends. That in England people paid to join the Royal Society, rather than joined to be paid as in the French Academie, indicated the health of British science. As to French predominance in mathematics: "Fashion to a certain extent prevails in the affairs of every country, but it predominates chiefly in France"[19] and provided the explanation for the particular galaxy of talent clustered around Laplace. Thus what one observer viewed as the decline of the most central sciences, the other saw simply as the result of national differences in style.

At least as interesting as these stark disagreements over measures and meanings is the range of the indicators neglected by all participants in the debate. Some of these indicators were easily available. Others emerge only with hindsight.

It would be unreasonable to expect the discussants to have seen 1830 as the year in which Charles Lyell was bringing to fruition his Principles of Geology. Charles Darwin was moving at increasing pace toward the Beagle voyage, and Michael Faraday stood on the brink of discovering electromagnetic induction. It was to be decades before the immensity of the achievement of each of these three giants of science would become fully apparent. Yet each was embarked on his particular path in 1830 -- a year in which serious men could passionately debate the decline of English science. This should give pause to all concerned to measure current science. Present awareness may be wider and present information systems better. Yet the enterprise to be measured is incomparably more

complex than that with which Moll and Babbage dealt, and there is little to suggest that available tools for appraising its intellectual vitality are significantly better.

The work of Darwin, Faraday, and Lyell was "hidden" in 1830. Not so other important indicators. Babbage and his contemporaries sought to appraise the familiar aspects of their world -- Government science, university research, the world of the Royal Society and the high elite. In retrospect, it is possible to appreciate the extent to which the cultural locus of science was shifting, without their knowledge. The most salient indicators of the health of English science actually lay in the rate of formation of metropolitan discipline societies, of provincial "literary and philosophical" associations, of natural history clubs, of statistical and agricultural societies, and of mechanics' institutes with their classes for chemistry and astronomy. Also important but equally neglected by the debaters was the tremendous growth in textbook and encyclopedia publishing, the emergence of a popular journal literature of science, and the dramatic expansion of teaching and learning opportunities through the activities of itinerant lecturers, mathematical practitioners, instrument-makers, and medical entrepreneurs.[20]

All this activity well indicates the progressivist orientations which guaranteed not decline but unprecedented growth on the high level which so concerned Babbage and Moll (and which depended for its health and vitality on this hidden infrastructure). Reflection on Babbage's failures -- shared equally by his most passionate supporters and his most determined opponents -- highlights both the difficulties in obtaining consensible indicators and the dangers inherent in a too narrow, ahistoric definition of measures appropriate for assaying the health of science.

Conclusions

There can be no single conclusion to this essay, for its purpose has been to hint at the complexities which necessarily beset any attempt to measure the health of science.

Perhaps it is sufficient to observe that Science Indicators 1972 and its successors assume an autonomy for the natural sciences which may better reflect the statutory jurisdiction of the National Science Foundation than the social reality in which the sciences actually function. The problematic nature of the assumption points toward the urgent need for better theoretical understandings of science from the perspectives of the sociology of knowledge. Were more of those understandings available, we would be able to state with greater confidence what sorts of social and cognitive data would provide reliable indicators of coming shifts in sentiment about particular sciences, as about the whole scientific enterprise.

Perhaps it is also worth pointing out the difficulties inherent in a focus on "science indicators" rather than some such holistic category as "knowledge indicators." For instance, SI-72 reports on the growth in natural science Ph.D.s with time, suggesting a "healthy" state. Yet such Ph.D.s decrease relative to social science Ph.D.s -- information which indicates quite different and possibly more significant aspects of the change. Again, the widening ripple

of repercussions from the simple perception that "student shortage" will be the pattern of the next two decades suggests that the financing of university science must be understood primarily in terms of the place of universities in the larger society.

Perhaps also a greater awareness of the several traditions in measuring science which have flourished from time to time might encourage both policy-makers and scholars to more imaginative investigations. If so, a knowledge of past controversies like that surrounding Charles Babbage's claims may save them from immodest claims about the meaning if not the reality of the measurement of science.

NOTES

1. This subject is explored in the various papers given at a "Conference on the History of Quantification in the Sciences" and published in Isis 52, No. 168, 1961.

2. See Science Indicators 1972 (Washington, D.C.: U.S. Government Printing Office, 1973); Science Indicators 1974 (Washington, D.C.: U.S. Government Printing Office, 1975); and Science Indicators 1976 (In press: publication expected in early summer 1977). Quotation from Science Indicators 1972 (SI-72), p. iii.

3. A first review conference on science indicators was held at the Center for Advanced Study in the Behavioral Sciences in Stanford, California in 1974. The 1976 Meeting of the American Association for the Advancement of Science, in Boston, devoted a session to the subject. A volume of essays is now in press: Yehuda Elkana, Joshua Lederberg, Robert K. Merton, Arnold Thackray, and Harriet Zuckerman, eds., Toward a Metric of Science: Essays Occasioned by the Advent of Science Indicators (New York: Wiley Interscience, publication expected in fall 1977).

4. That history is discussed more fully in my "Measurement in the Historiography of Science" in Toward a Metric of Science.

5. Henry Thomas Buckle, A History of Civilization in England, 4th ed., 2 vols. (London: Longman, Green, etc., 1864); quote from vol. 1, p. 6.

6. See e.g., Eggleston's The Transit of Civilization (New York: Appleton, 1901); Merz's A History of European Thought in the Nineteenth Century, 4 vols. (London: W. Blackwood and Sons, 1903-1914); Sorokin's Social and Cultural Dynamics, 4 vols. (New York: American Book Company, 1937).

7. William F. Ogburn, Social Change with Respect to Culture and Original Nature (New York: B.W. Huebsch, 1923. Reprinted with an Introduction by O.D. Duncan, University of Chicago Press, Chicago, 1964. Quotation at p. xi of the reprint edition).

8. See the Introduction by Norman W. Storer in Robert K. Merton, The Sociology of Science (Chicago: University of Chicago Press, 1973) and Jonathan R. Cole and Harriet Zuckerman, "The Emergence of a Scientific Specialty: The Self-Exemplifying Case of the Sociology of Science," in Lewis A. Coser, ed., The Idea of Social Structure: Essays in Honor of Robert K. Merton (New York: Harcourt Brace Jovanovich, 1975), pp. 139-174.

9. F.J. Cole and Nellie B. Eames, "The History of Comparative Anatomy: A Statistical Analysis of the Literature," Science Progress 11 (1917): 578-596; and E.W. Hulme, Statistical Bibliography in Relation to the Growth of Modern Civilization (London: Butler & Tanner, Grafton & Company, 1923).

10. See Ming Ivory, Janice LaPorte, Henry Small, and Janet Stanley, Citation Analysis: An Annotated Bibliography (Philadelphia: Institute for Scientific Information, 1976); and Francis Narin, Evaluative Bibliometrics: The Use of Publication and Citation Analysis in the Evaluation of Scientific Activity (Cherry Hill, New Jersey: Computer Horizons, Inc., 1976).

11. See e.g., J. McK. Cattell, "Homo Scientificus Americanus," Science 17 (1903): 561-570. A fuller discussion and extended citations appear in my "Measurement in the Historiography of Science."

12. Again, a fuller discussion and extended citations appear in my "Measurement" paper.

13. See especially her Natural Symbols (London: Barrie and Rocklift, 1970).

14. See e.g., Henry Rowland, "A Plea for Pure Science," Science 2 (1883): 242-250; Harry W. Paul, "The Issue of Decline in Nineteenth-Century French Science," French Historical Studies 7 (1972): 416-450; Charles Babbage, Reflections on the Decline of Science in England (London: B. Fellowes, 1830).

15. For a brief discussion of the "decline" debate, see pp. 152-157 of A.D. Orange, "The Origins of the British Association for the Advancement of Science," British Journal for the History of Science 6 (1972): 152-176. J.B. Biot, "[Review of] Reflections on the decline of science in England...," Journal des Savans (January 1831: 41-49; and [Gerard Moll], On the Alleged Decline of Science in England (London: T. & T. Boosey, 1831) provide some indication of the range of European reaction to Babbage's philippic.

16. Babbage, Decline of Science, p. v.

17. Ibid., pp. viii-ix.

18. Ibid., pp. 9-10.

19. Moll, Alleged Decline, p. 11.

20. For further discussion, see J.B. Morrell, "Individualism and the Structure of British Science in 1830," Historical Studies in the Physical Sciences 3 (1971): 183-204; and Steven Shapin and Arnold Thackray, "Prosopography as a Research Tool in History of Science: The British Scientific Community 1700-1900," History of Science 12 (1974): 1-28.

V. ADDITIONS TO GENERAL BIBLIOGRAPHY

Aaronson, Steve. "The Social Cost of Earthquake Prediction." New Scientist, 17 March 1977: 634-636.

Seismologists developing the ability to predict damaging earthquakes are beginning to realize that the costs of the service involve more than the expense of equipment and scientific personnel. This article reports the findings of a research team that has been studying the social, political, and economic effects of prediction.

Abelson, Philip H., and Irene Tinker. "Technology Transfer." Science 195, 28 January 1977: 351.

This editorial criticizes the past neglect and current naivete of politicians regarding the transfer of Western technology to the non-Western world.

Alexander, Tom. "It's Time for New Approaches to Pollution Control." Fortune 94, November 1976: 129 ff.

Subtitled: "If we persist on the present regulatory paths, costs will outweigh benefits and, oddly enough, the environment may get dirtier."

Anderson, Alan, Jr. "Scientist at Large." New York Times Magazine, 7 November 1976: 58.

A profile of Barry Commoner: "Barry Commoner's hip rhetoric and moral fervor have gained the enmity of industry, the mistrust of labor, and the envy and outrage of his peers."

Back, William B. "The ERS (Economic Research Service of the U.S. Dept. of Agriculture) Workshop on Technology Assessment: An Overview." Journal of the International Society for Technology Assessment 2, Fall 1976: 9-12.

Senior Research Economist for the ERS, Mr. Back edited this issue of the Journal, which is entirely devoted to agricultural technology assessment. His own article presents an overview of the workshop from which many of the papers come. The papers include a historical survey of the ERS, discussions of methods of technology assessments, and reports on assessments of specific technologies.

Bhaneja, Balwant. "India's Science and Technology Plan, 1974-79." Social Studies of Science 6, February 1976: 99-104.

Black, Max. "The Objectivity of Science." Bulletin of the Atomic Scientists 33, February 1977: 55.

A philosopher's defense of objectivity in science. "There is something charmingly absurd about a skeptic who, while disclaiming the possibility of knowledge by the means that we have found to be most reliable, still affirms confidentially that he knows that scientists cannot know anything....There

is no half-way house between skeptical rejection of the cognitive claims of science and a total skepticism that reduces its advocates to silence."

Boffey, Philip M. "The New York Academy of Sciences: A Bid for Greater Influence." Science 195, 7 January 1977: 35-36.

A description of a major effort, recently launched by the New York Academy of Sciences, an organization with 26,000 members, to become active in public policy and exert influence on the general public and its political leaders.

Branson, Roy. "Prison Research: National Commission Says 'No, Unless...'." Hastings Center Report, February 1977: 15-21.

In the fall of 1976, the National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research issued recommendations concerning the use of prisoners in nontherapeutic biomedical research. Its unanimous recommendations were made only after considerable debate and disagreement. This article examines the "anatomy" of the decision by looking at the way the Commission arrived at its conclusions and by seeing how it related ethical concerns to specific policy recommendations.

Brooks, Harvey. "U.S. Science and Technology: A Prescription for 'Health'." Science 195, 11 February 1977: 536.

In a letter to the editor, Professor Brooks, as chairman of the Congressional Office of Technology Assessment's advisory panel on the health of the scientific and technological enterprise, requests views on: "(i) what issues should be given priority on our agenda, (ii) what some of the perceived problems and strengths of the present system of overall management and support of research and development in the United States are, and (iii) how the future system might look." (For the complete text, see pp. 13-14 of this issue of the Newsletter.)

Bullough, Bonnie, ed. The Law and the Expanding Nursing Role. New York: Appleton-Century-Crofts, 1975.

Reviewed by Miriam Manisoff in Family Planning Perspectives 8, May/June 1976: 138: "One response of health care delivery systems around the world to pandemic physician shortages has been the delegation of more responsibility for medical care to nurses and other specially trained nondoctors....Bullough's book focusses on the legal barriers to the expanded role of the nurse in the United States, and suggests various means by which these may be overcome. The history of nursing and medical licensure in this country provides some fascinating background."

Burger, Edward J., Jr. "Effective Institutions for Presidential Science Advice." Technological Forecasting and Social Change 9, 1976: 337-347.

The author was a member of the staff of the Office of Science and Technology from 1969-73. When giving scientific advice on major policy decisions (as opposed to funding research) explicit planning has been difficult to maintain against politics. "In the opinion of this writer, the major tasks of analysis

and study for policy-making for domestic matters may eventually have to be performed not within but outside the structures of government."

Bylinsky, Gene. "Future Drugs That Will Be Lifesavers for the Industry Too." Fortune 94, December 1976: 153-162.

Subtitled: "Scientists have penetrated the ultimate stronghold of pathology, the cell. Their discoveries are yielding a new generation of natural wonder drugs."

Bylinsky, Gene. "Green Plants Might Provide the Cheapest Energy of All." Fortune 94, September 1976: 152-157.

"Scientists are finding ways to redirect photosynthesis -- the fundamental source of food -- to produce hydrogen, the fuel of the future."

Campbell, Donald C. "On the Conflicts between Biological and Moral Tradition." Zygon 11, September 1976: 167 ff.

Presidential address to the American Psychological Association in 1975, also printed in American Psychologist 30, 1975: 1103-26. Campbell presents an evolutionary epistemology, using the concepts of biological evolution to understand intellectual history. He regards scientific knowledge as a useful but not absolutely true adaptation to our environment: "All scientific knowledge is indirect, presumptive, obliquely and incompletely corroborated at best. The language of science is subjective, provincial, approximative, and metaphoric, never the language of reality itself....The best we can hope for are well-edited approximations." The issue also contains several commentaries on Campbell's article.

Carter, Jimmy. "Three Steps toward Nuclear Responsibility." Bulletin of the Atomic Scientists 32, October 1976: 8-14.

Written during the Presidential campaign, the article argues for "action to meet the energy needs of all countries while limiting reliance on nuclear energy, action to limit the spread of nuclear weapons, and action to make the spread of peaceful nuclear power less dangerous."

Carter, Luther J. "Failure Seen for Big-Scale, High-Technology Energy Plans." Science 195, 25 February 1977: 764.

Summary of a recent report by a task force of environmentalists which recommended a phase-out of nuclear power, a major shift away from large-scale high-technology energy development, and instead, a two-pronged strategy of cutting energy demand by half through conservation and developing "soft" technologies such as solar heating and cooling, wind power, and conversion of organic matter.

Carter, Luther J. "Nuclear Partners: Adversity Breeds Trouble between Dow and Utility." Science 195, 14 January 1977: 162-163.

Details of the disagreements between Dow and Michigan's Consumers Power Com-

pany over the construction of a nuclear power plant. Scheduled to be completed by 1975, the plant is now only 20 percent complete and will not be fully operating until 1982 at the earliest.

Carter, Luther J. "PR Man Helps Select Author of Book on Pollution Study Case." Science 195, 4 February 1977: 468.

A case study on the publishing of a book on a controversial topic for a popular audience. Frank D. Schaumberg's Judgment Reserved: A Landmark Environmental Case criticizes environmentalists involved in the Reserve Mining Case on Lake Superior. Science reports that Schaumberg was suggested as the author for such a book by a public relations consultant for Armco Steel Corporation, which, with Republic Steel, owns and controls Reserve Mining; and that Armco agreed to purchase 10 percent of the first press run.

Carter, Luther J. "Radioactive Wastes: Some Urgent Unfinished Business." Science 195, 18 February 1977: 661-666.

A historical survey of waste disposal efforts and current efforts by ERDA to develop six geologic depositories for commercial wastes. The article concludes by listing key policy questions still to be resolved: the disposal of military wastes, fuel reprocessing and recycling of plutonium, disposal of wastes from nuclear power plants built in developing countries, and the possibility of international cooperation in disposing of wastes beneath the deep seabed.

Casper, Barry M. "Laser Enrichment: A New Path to Proliferation." Bulletin of the Atomic Scientists 33, January 1977: 28-41.

"Researchers are on the track of a far easier and cheaper method of producing weapons-grade uranium; the U.S. should take stock of the implications before deciding whether to allow its development to continue."

Chow, Brian G. "The Economic Issues of the Fast Breeder Reactor Program." Science 195, 11 February 1977: 551-556.

The author questions the claimed economic advantages of fast breeder reactors: "The economic benefits of the LMFBR program claimed by the AEC cannot be accepted at face value. Doubts raised here and elsewhere should be examined in detail....ERDA should internalize (include) the environmental and social costs of the LMFBR program in their cost-benefit analyses and...compare the results with those of alternative energy options."

Cohen, Stanley N. "Recombinant DNA: Fact and Fiction." Science 195, 18 February 1977: 654-657.

A defense of the NIH guidelines by one of those originally calling for guidelines, who now feels that "what began as an act of responsibility by scientists...has become the breeding ground for a horde of publicists -- most poorly informed, some well-meaning, some self-serving." He presents basic information on recombinant techniques, then discusses issues of freedom of

scientific inquiry, interference with "evolutionary wisdom," benefits of the research, and the specific NIH guidelines.

Coleman, Jerry Peter. "International Safeguards against Non-Governmental Nuclear Theft: A Study of Legal Inadequacies." The International Lawyer 10, Summer 1976: 493-514.

Culliton, Barbara J. "Ford's Farewell Budget: Science Fares Quite Well." Science 195, 28 January 1977: 374-376.

An analysis of funding for science in President Ford's budget, much of which will probably be kept by Carter.

Culliton, Barbara J. "Harvard and Monsanto: The $23-Million Alliance." Science 195, 25 February 1977: 759-763.

A report on the history of Monsanto's agreement with Harvard to finance research to isolate a possible chemical signal solid tumors may send out to stimulate the growth of blood vessels, in return for the patent rights to any fruits of the research.

Day, Samuel H., Jr. "Converting the Weapons Lab." Bulletin of the Atomic Scientists 33, January 1977: 27.

Brief report on the University of California Weapons Lab Conversion Project, a group questioning U.C.'s contracts to operate nuclear weapons labs at Los Alamos and Livermore, and suggesting alternative subjects for research and development.

Dubos, Rene. "The Despairing Optimist...." The American Scholar 46, Winter 1976/77: 10-18.

An essay on current criticisms of modern medicine. The author concludes: "Modern physicians have given up the props of their predecessors and have greater confidence in scientific knowledge than pomposity or even loving care....On the other hand, it is still true that a very large percentage of the physical and mental ailments that lead people to seek medical help can be corrected by ways of healing that do not depend on scientific analysis. In the final analysis, most ways of healing depend on self-healing....Medicine will not become fully scientific until it has come to grips with the problems of social pathology and of emotional disturbances, as well as with the mechanisms that Osler had in mind when he wrote of 'the faith that heals.'"

Durham, Tony. "The Consumer and the Black Box." Science and Public Policy 3, October 1976: 436-439.

The author writes: "In this century, both science and technology seem to be deliberately veiled from the public. If science, in the public mind, is hidden behind a white coat, then technology is concealed in a 'black box'.... By using 'advanced' materials and fabrication techniques and 'higher' technology generally, the boss has also increased his control over the consumer.... This control acts through the products themselves, and is far less resistant than the more celebrated control of the consumer by advertising and the media."

Elliott, David, and Ruth Elliott. The Control of Technology. London and Winchester: Wykeham Publications [London], Ltd., 1976.

A discussion of the interaction between modern society and technology, with particular concentration on the forces which control this interaction. The authors' perspective is stated in their Preface: "Man needs some form of technology to survive in any society. It is not the existence of 'technology' itself that is the problem, but rather the precise forms of contemporary technology. As such, the question of 'technology' is inseparable from questions of social, economic, and political structure. Thus in order to explore the topic of the control of technology, we find that we have to address the much larger problem of control of society in economic and political terms."

Federation of American Scientists. "Comments on the December Issue on Scientific Responsibility." F.A.S. Public Interest Report 30, February 1977: 7-8.

Comments by a number of scientists, including Alvin Weinberg, on an earlier editorial arguing that public interest scientists should evolve new standards of conduct to resolve "the novel dilemmas posed by conflicts between responsibility to science on the one hand and to citizenry on the other."

Federation of American Scientists. "Issues in the Health of Science." F.A.S. Public Interest Report 30, January 1977: 1-6.

A series of short articles on the ages and fields of scientists, with suggestions for government action to maintain the health of science.

Federation of American Scientists. "Scientific Responsibility." F.A.S. Public Interest Report 29, December 1976: 1-7.

Several short articles asking to whom public interest scientists are responsible (the scientific community or the public) and how this responsibility can be expressed in standards dealing with practical problems, such as when to speak out, how to phrase conclusions, and how to get the public's attention. The simple view that scientists provide "facts" and policy-makers then make choices is no longer adequate. There is a brief article on the approaches of Bernal and the Chinese Communists. Readers were invited to comment.

Feiveson, Harold A., et al. "The Plutonium Economy: Why We Should Wait and Why We Can Wait." Bulletin of the Atomic Scientists 32, December 1976: 10-21, 46-56.

The article discusses the plutonium problem in general, the reduction in hazard which would result from using thorium, and the greater time for decision which would result from more efficient energy use.

Flowers, Sir Brian. "A Watchdog's View." Bulletin of the Atomic Scientists 32, December 1976: 24-27.

The author was chairman of the British Royal Commission on Environmental Pollution during preparation of the recent report on nuclear power and the environment, urging caution in developing nuclear power. He presents his views on nuclear power.

Fraser, John. "Louis Althusser on Science, Marxism and Politics." Science and Society 40, Winter 1976/77: 438-464.

A severe criticism of Althusser's Marxist philosophy of science by another Marxist: "The epistemology employed by Althusser is derived from a psychologistic philosophy of science whose historical relativism and conventionalism Althusser disregarded. It is not a Marxist, materialist epistemology, and is even anti-Marxist in its subjectivity and emphasis on the crucial historical role of the conceptualizer....The reformulations of the relations of theoretical generalities such as science, philosophy, and politics are ultimately unsatisfactory since they are never given definitions and concrete referents which might make their rearrangement less arbitrary and more meaningful."

Fuller, Robert F., Robert Karplus, and Anton E. Lawson. "Can Physics Develop Reasoning?" Physics Today 30, February 1977: 23-28.

Using Piaget's concepts, the authors argue that "the physics community has chosen to isolate itself from individuals using primarily concrete reasoning patterns....In short, our fixation on the formal aspects of physics instead of its concrete experiences has made physics unnecessarily difficult and dry. We have removed the sense of exploration and discovery from the study of physics." The authors urge greater use of Piaget's insights in teaching physics, and list several programs currently doing so.

Gilbert, G. Nigel. "The Transformation of Research Findings into Scientific Knowledge." Social Studies of Science 6, September 1976: 281-306.

A theoretical discussion by a sociologist of "the process whereby a scientist's research findings are transformed into accredited factual knowledge....In contrast to the epistemological concerns of the philosophers, I shall be considering only the procedures actually used by natural scientists to decide on the validity of claims to scientific knowledge." The author employs data from a recently completed study of a problem area known as "Radar Meteor Research."

Gold, Bela, ed. Technological Change: Economics, Management and Environment. New York and Oxford: Pergamon Press, 1975.

Reviewed by Richard S. Rosenbloom in Technology and Culture 17, October 1976: 782: "six essays by the five authors that add up to a penetrating and persuasive critique of the accepted findings -- and what Gold terms the 'prevailing mythology' -- about the adoption of innovations and economic consequences of technological change....Gold and his colleagues argue that future research should seek to penetrate the 'black box' in which economists load the behavioral and other factors beyond the reach of their aggression models.... It (the book) also reflects a grasp of the influence of managerial choice in shaping the rate and direction of innovation and its consequences."

Gore, Peter H., and Mark B. Lapping. "Environmental Quality and Social Equality: Wilderness Preservation in a Depressed Region, New York State's Adirondacks." American Journal of Economics and Sociology 35, October 1976: 349-359.

"Abstract: The problems and contradictions which arise when an economically 'poor' region is mandated to remain environmentally 'pure' are examined.... This limitation on development for environmental reasons has serious consequences for the 120,000 permanent residents within the park boundaries who, through their legislators, vigorously opposed the controls. A number of examples of the conflicts which have arisen are cited and a framework for comprehensive rather than fragmented planning is suggested."

Gorove, Stephen. "Solar Energy and Space Law." The International Lawyer 10, Summer 1976: 531-536.

Hammond, George S. "The Value System in the Scientific Subculture." Bulletin of the Atomic Scientists 32, December 1976: 36-40.

The author, a professor of chemistry at the University of California, treats science as a culture and criticizes several current values in science: mathematical rigor, the eternal value of "fundamental concepts," current disciplinary divisions, scientific "purity," the universal value of all science, and objectivity (embodied in impersonal prose). He concludes: "Serious consideration of societal problems, even those of technology, will demand sacrifice of cherished ideals of rigor and purity."

Hardin, Garrett. "Living with the Faustian Bargain." Bulletin of the Atomic Scientists 32, November 1976: 25-29.

Written by the author of "Tragedy of the Commons," the article considers the human element in nuclear reactor safety. "A safe system of atomic energy production is possible only in a society in which there is a 'sense of community,' a sense of mutual obligation among the people sharing a common energy system....We seek atomic energy because tribalism keeps us from considering population control measures; but tribalism threatens the safety of the atomic energy system....That is the cruel paradox we must live with."

Hardin, Garrett, and John Baden, eds. Managing the Commons. San Francisco: W.H. Freeman and Co., 1977.

This anthology of readings explores the implications of "The Tragedy of the Commons" -- the management of the world's common resources and the limitations to individual freedom which it entails -- for modern society. The readings trace the development of the concept of the commons and focus on ways in which the cultural norm of independence of individual action may be changed to promote continued human welfare and survival. The collection includes historical and recent essays, original material by the editors, and a new essay by Kenneth Boulding.

Hirshberg, Alan S. "Public Policy for Solar Heating and Cooling." Bulletin of the Atomic Scientists 32, October 1976: 37-45.

Removal of the institutional barriers and provision of incentives would greatly boost the impact of solar energy on the U.S. economy and stimulate impressive savings in fossil fuel use.

Houston, Jean. "Prometheus Rebound: An Inquiry into Technological Growth and Psychological Change." Technological Forecasting and Social Change 9, 1976: 241-258.

Abstract: "Western man's philosophy of power over nature has led to the present excess of technology. The technological environment, in turn, has had profound and questionable influence on the human physiological and psychological organism -- resulting frequently in both personal and social breakdown. The body-mind needs a new kind of nurturing and educational process involving the potentiation of latent human capacities if it is to successfully withstand and recreate the technological process, as well as facilitate a more humane use of human beings."

Huddle, Norie, and Michael Reich, with Nahum Stiskin. Island of Dreams: Environmental Crisis in Japan. Box 469, Kanagawa, California 95073: Autumn Press, 1975. (The book is distributed by: Book People, 2940 Seventh Street, Berkeley, California 94710.)

Uncontrolled industrialization has pushed Japan to the brink of environmental disaster. Reviewed by Frank von Hippel in Bulletin of the Atomic Scientists 33, January 1977: 63-64.

Hughes, Thomas Parke. "The Science-Technology Interaction: The Case of High-Voltage Power Transmission Systems." Technology and Culture 17, October 1976: 646-662.

"There has been a strong tendency in the history of science and technology to explain complex technological change with primary reference to antecedent scientific discoveries. The science-technology relationship has been thought to be technology's strongest. The major thesis of this paper, however, is that the evolving technology of the high-voltage transmission system -- a major chapter in the history of electric light and power -- can best be explained by reference to needs arising within that system rather than by attribution to science."

Hunt, Robert, and John Arras, eds. Ethical Issues in Modern Medicine. Palo Alto, California: Mayfield Publishing Co., 1977.

This anthology is designed particularly for the student with no formal training in ethics. The Introduction includes a discussion of major ethical theories, and there are chapters on: Genetics; Abortion; Euthanasia; Informed Consent; Behavior Control and Psychosurgery; Justice, Social Policy, and the Province of Medicine.

Institute on Human Values in Medicine. Human Values Teaching Programs for Health Professionals: Self-Descriptive Reports from Twenty-Nine Schools. 3rd ed. (Philadelphia, Pennsylvania: Society for Health and Human Values, 1976. Report No. 7).

This is a compilation of teaching programs for students in the health professions, which include medical ethics, philosophy, literature, history, and the social and behavioral sciences.

Jackson, R.W. Human Goals and Science Policy. (Background Study No. 38; Science Council of Canada, 150 Kent Street, Ottawa, Ontario K1P 5P4, Canada, 1977.)

This study examines the connections between personal and social needs and aspirations, national goals, and political decision-making in a pluralistic democracy, especially in matters affecting or affected by science and technology.

Jevons, F.R. "The Interaction of Science and Technology Today, or, Is Science the Mother of Invention?" Technology and Culture 17, October 1976: 729-742.

The author discusses British attempts to quantify the benefits of applying discoveries of "pure" research, the inadequacies of that approach, and other studies arising from a rejection of the view that scientific discoveries lead to technological innovations. In particular, the author studied the sources of information used to develop technological innovations. An average of thirty information inputs per innovation was discovered -- discounting the view that most innovations arise from a single scientific discovery.

Koblinsky, Marjorie A., Frederick S. Jaffe, and Roy O. Greep. "Funding for Reproductive Research: The Status and the Needs." Family Planning Perspectives 8, September/October 1976: 212-225.

A statistical summary of funding for research in human reproduction, with recommendations for the future.

Layton, Edwin T., Jr. "American Ideologies of Science and Engineering." Technology and Culture 17, October 1976: 688-701.

The author argues that science and technology have a symbiotic relationship, perceived in three different ideologies: basic science (intellectual parasitism), engineering science (recasting engineering science in the form of science), and design (purposive adaptation of means to reach a preconceived end). "The ideologies of science and technology thus provide three quite different views of their interaction....For a complete picture, the insights of all three will have to be incorporated in our historiography."

Leeper, E.M. "Research Support Grows in Federal R&D Budgets." Bio Science 27, March 1977: 161-163.

An analysis of President Ford's FY 1978 budget.

Lewin, Roger. "U.S. Genetic Engineering in a Tangled Web." New Scientist, 17 March 1977: 640-641.

The author observes that recombinant DNA researchers in the U.S. are "at the center of a web of powerful arguments" and suggests that the answer is the "rapid enactment of effective legislation to control the research in universities and industry." A contrast is drawn with the situation in Great Britain, which, says Lewin, is now "calm and unruffled."

Long, F.A. "Peaceful Nuclear Explosions." Bulletin of the Atomic Scientists 32, October 1976: 18-28.

A report on two recent studies casting further doubt on the feasibility of putting the explosive power of the atom to beneficial use.

Lynn, Walter R. "Engineering and Society Programs in Engineering Education." Science 195, 14 January 1977: 150-155.

Despite the proliferation of academic programs on science, technology, and society, and despite the pertinence of such programs to engineering, they have rarely been incorporated into engineering education. The author attempts to explain why this is so and to suggest ways by which the situation might be changed.

MacKenzie, Donald. "Eugenics in Britain." Social Studies of Science 6, September 1976: 499-532.

The author argues that early twentieth century eugenics should be viewed as "an ideology of the professional middle class, and in particular of the 'modern' (school-teaching, science and engineering, etc.) rather than the 'traditional' (church, law and medicine) sector....Eugenic ideas can be regarded as a set of tools deployed for social purposes. The ideas were taken up when thought likely to be useful to their carrier group, and later, when changed circumstances made them less appropriate, they were discarded."

MacRae, Duncan, Jr. "Technical Communities and Political Choice." Minerva 14, Summer 1976: 169-190.

A discussion of the difficulty of combining expert advice with democratic institutions. Should advisers be chosen and judged by their status within a scientific community when advice is sought on matters beyond the competence of that community? Or should we instead develop technical communities concerned with the applications of science rather than with basic research? The author discusses the characteristics of these different communities.

Mandelbaum, Michael. "A Nuclear Exporters Cartel." Bulletin of the Atomic Scientists 33, January 1977: 42-50.

The author describes how such a cartel might slow nuclear proliferation.

Mathias, Sen. Charles, Jr. "The Fourth Amendment in the Electronic Age." Jurimetrics Journal 17, Winter 1976: 131-137.

The entire issue contains papers on "Emerging Legal Issues and the Impacts of Electronic Data Processing."

Mayr, Otto. "The Science-Technology Relationship as a Historiographic Problem." Technology and Culture 17, October 1976: 663-673.

The author discusses what historians have contributed to our understanding of the science-technology interaction, and what they could contribute. He

argues that "all attempts to arrive at a single grand solution of the problem are illusory and bound to fail" and suggests more attention should be paid the variety of concepts labeled "science and technology." He suggests "we should recognize that the concepts of science and technology are themselves subject to historical change; that different epochs and cultures had different names for them, interpreted their relationship differently, and, as a result, took different practical actions."

Milunsky, Aubrey, and George J. Annas. Genetics and the Law. New York: Plenum Publishing Corp., 1976.

Reviewed by Eve Paul in Family Planning Perspectives 8, November/December 1976: 299-300: "a collection of 30 papers presented by scientists, physicians and lawyers at a 1975 national symposium co-sponsored by the Boston Chapter of the National Genetics Foundation and the American Society of Law and Medicine. The book also includes transcripts of the discussion of such subjects as the fetus and the newborn; genetic counseling and mass population screening; genetics and family law; research and experimentation; and an overview of eugenics, ethics, law and society."

Mulkay, Michael. "The Mediating Role of the Scientific Elite." Social Studies of Science 6, September 1976: 445-470.

The article considers "the ways in which external influences impinge on the development of science and scientific knowledge" and the role of the scientific elite in mediating these forces. The author argues that "this elite, having been created primarily by social processes occurring inside the research community, remains strongly committed to objectives regarded as central within that community." Finally, the author illustrates the role of the scientific elite in Britain as a "buffer group" which resists external demands to maintain "considerable freedom for members of the academic research community to pursue their own 'scientifically defined' interests."

National Science Foundation. An Analysis of Federal R&D Funding by Function, Fiscal Years 1969-1977. (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; $2.45. Stock number: 038-000-00298-8.)

Provides data on Federal research and development programs in terms of functions such as natural defense, space, health, and energy. The report is designed to indicate Federal R&D priorities. It is concerned with broad trends and relationships for the various functions throughout the nine-year period, and with the detailed treatment of each function.

National Science Foundation. Characteristics of the National Sample of Scientists and Engineers, 1974. Part 2. Employment. (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; price, $2.80; stock number 038-000-00-306-2.)

Presents employment information on scientists and engineers who were already in the labor force at the time of the 1970 Census. The data were collected from those who responded to the 1974 National Survey of Scientists and Engineers. The report includes detailed tables describing employment character-

istics such as employment status, salaries, types of employers, and primary work activities by field.

National Science Foundation. Recent RANN Reports. (NSF/RA - 770014; available by writing to George James, RANN Communications, Room 1108, National Science Foundation, 1800 G Street, N.W., Washington, D.C. 20550.)

This 43-page publication cites about one hundred reports received by NSF from researchers supported by its Research Applied to National Needs (RANN) program. The citations are compiled periodically by the NSF to alert the scientific and technical community to current research results. The publication also tells how copies of the cited documents may be obtained from the National Technical Information Service (NTIS).

National Science Foundation. Research and Development in Industry, 1974. (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; $2.00 per copy; stock number 038-000-00296-1.)

The report provides statistics on industrial research and development by source of financing, character of work, and geographic distribution. Data on basic research are presented by field of science, and details on applied R&D are shown by product field.

National Science Foundation, U.S. Scientists and Engineers: 1974. (Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402; price, $1.25; stock number 038-000-00302-0.)

This report presents data on the demographic, employment, and geographic characteristics of U.S. scientists and engineers. Information is given in terms of science fields, sex, race, age, education, and other attributes.

Nelkin, Dorothy. Science Textbook Controversies and The Politics of Equal Time. Cambridge, Massachusetts: MIT Press, 1977.

A study of several controversies over the content of the natural and social science textbooks and courses that were promulgated as part of the post-Sputnik science curriculum effort. The book focusses on two controversies: the reactions to the teaching of evolution in public schools, and the conflict over the course, "Man: A Course of Study" (MACOS). These and other controversies are analyzed to suggest their origins in broad social and political concerns.

Norman, Colin. "Overheads: A Growing Problem." Nature 265, 10 February 1977: 488-489.

A report of a growing dispute involving overhead costs associated with government-funded research.

Palfreman, Jon. "William Crookes: Spiritualism and Science." Ethics in Science and Medicine 3, December 1976: 211-227.

The paper examines the researches into the phenomena of Spiritualism undertaken by the eminent Victorian chemist, William Crookes (c. 1870-1875), and

the corresponding reaction of the scientific community.

Pomerance, Jo. "The Anti-Test Ban Coalition." Bulletin of the Atomic Scientists 33, January 1977: 51-54.

An advocate of a comprehensive nuclear weapons test ban treaty, the author reviews the history of resistance to this effort and concludes that the new President will have his work cut out if he hopes to overcome this opposition.

Pugwash Council. "Disarmament, Security and Development." Bulletin of the Atomic Scientists 32, December 1976: 28-33.

Adapted from a statement of the Pugwash Council summarizing the findings and conclusions of the 1976 meeting, held August 26-31, among 87 scientists from 28 countries.

Randal, Judith. "Life from the Labs: Who Will Control the New Technology?" The Progressive 41, March 1977: 16-20.

Discussion of the recombinant DNA controversy for lay readers. The author describes the problem and poses the issues, but does not advocate any detailed solution.

Ritterbush, Philip C. "Public Understanding of Science and Technology." Science and Public Policy 3, October 1976: 400-433.

The author writes: "Our arrangements for popular science education took form before science and technology had the full range of social effects they now exert and before public policies regarding science were extensively formulated...." He considers the relation of popular experience to the future life of science and discusses specific problems of educating the public to contribute to science policy.

Rochlin, Gene I. "Nuclear Waste Disposal: Two Social Criteria." Science 195, 7 January 1977: 23-31.

Although it is generally agreed that "radiologically hazardous wastes from the nuclear fuel cycle should be separated from the biosphere to a sufficient degree and for a long enough time so that they present no significant risk to life," there is no consensus about the definitions of "sufficient," "long enough," or "significant risk." The author suggests two criteria -- technical irreversibility and site multiplicity -- for use in establishing standards for the disposal of nuclear wastes, so as to facilitate consideration of the normative and ethical aspects of these decisions.

Royal Commission on Environmental Pollution. "A Warning in Britain: Go Slow on Nuclear Power." Bulletin of the Atomic Scientists 32, December 1976: 22-23.

Excerpts of the conclusions and recommendations of the Commission's report, "Nuclear Power and the Environment," issued last September.

Science and Public Policy 3, October 1976: "Netherlands Science Policy for 1976" (pp. 467-468); "Social Scientific Research and Public Policy in the Netherlands" (pp. 468-471); "Swiss University and Research Policy" (pp. 471-473).

Shapiro, Mark. "Comment on 'Physics Teaching: Does It Hinder Intellectual Development?' (Am. J. Phys. 44: 81 (1976)." American Journal of Physics 45, January 1977: 89.

The author argues that we should provide remedial programs to increase the formal, logical ability of students instead of accommodating "concrete" thinkers by attempting to present physics in purely concrete terms.

Shapley, Deborah. "Will Fertilizers Harm Ozone as Much as SST's?" Science 195, 18 February 1977: 658.

The Berkeley physical chemist who first proposed that nitrogen oxide exhausts from supersonic transport planes might hurt the earth's protective ozone layer now says that nitrogen fertilizer -- upon which the world depends for an adequate supply of food -- could be just as harmful over a period of 160 years or more.

Shapo, Marshall S. "Swine Flu and Legal Policy: How well did the government do with its hard choices?" ABA Journal 63, January 1977: 50-54.

Sharlin, Harold A. "Herbert Spencer and Scientism." Annals of Science 33, 1976: 457-465.

This is one of three papers given at a joint session of the American Historical Association and the History of Science Society in December 1975. The subject of the session, entitled "Spencer, Scientism and American Constitutional Law," was Herbert Spencer's theories and their influence on American social and political history. The intent of the session was to show how the history of science, social and political history as well as intellectual history can find common ground in analyzing historical problems. The other two papers, also published in this issue of the journal, are "Social Darwinism and Constitutional Law with Special Reference to Lochner vs. New York," by Joseph F. Wall, and "Comments on Papers by Sharlin and Wall," by David A. Hollinger.

Sinsheimer, Robert. "An Evolutionary Perspective for Genetic Engineering." New Scientist, 20 January 1977: 150-152.

Sinsheimer, a prominent critic of recombinant DNA research, argues that the NIH guidelines ignore the important evolutionary divisions between viruses, bacteria, and humans.

Smil, Vaclav. "Intermediate Energy Technology in China." Bulletin of the Atomic Scientists 33, February 1977: 25-31.

A report on how large numbers of small-scale projects are strengthening the country's industrial base.

Stevens, Chandler Harrison. "Science Resource Network for Legislators and Citizens." Science and Public Policy 3, October 1976: 442-454.

A description of the Science Resource Network of the Massachusetts Legislature, which attempts to make scientific expertise available to legislators and citizens.

Tarlock, A. Dan. "Oil Pollution on Lake Superior: The Uses of State Regulation." Minnesota Law Review 61, November 1976: 63-125.

Teich, Albert, ed. Technology and Man's Future. 2nd ed. New York: St. Martin's Press, 1977.

This anthology is divided into three parts. Part One, "Scientists, Technologists, and the Future," presents the views of those who are primarily responsible for creating new technology: scientists and engineers. Part Two, "Technology and Philosophy," contains selections from the writings on technology of contemporary philosophers, as well as a debate on the place of technology in society between observers with different political perspectives. In Part Three, "Toward Assessment and Control," the concept of technology assessment and a variety of associated, recent ideas for the control of technology are presented and criticized.

Tobey, Ronald. "Theoretical Science and Technology in Ecology." Technology and Culture 17, October 1976: 718-728.

The author argues that American ecology was not simply the importation of European naturalism, which is described as "a static perspective" focussing on the plant in its habitat, but a "dynamic perspective, which studied the movement of plant communities through time." The author identifies the source of the rise in dynamism in ecology as the technological effort of University of Nebraska scientists under the leadership of Charles Bessy to control vegetational changes on the midwestern grasslands.

Tooze, John. "Genetic Engineering in Europe." New Scientist, 10 March 1977: 592-594.

After an initially slow response to the U.S. concern over research on recombinant DNA, European countries are now beginning to coordinate their efforts to regulate experiments and so minimize any hazard that might be associated with them. Tooze, an official of the European Molecular Biology Organization, reports on the administration of the issues in Europe.

Train, Russell E. "Environmental Cancer." Science 195, 4 February 1977: 443.

An editorial describing the EPA's plans to study correlations between cancer and specific chemicals in the air, water, and food of regions with high rates of certain cancers, and emphasizing the EPA's need for assistance from the larger segment of the scientific community.

Tsipis, Kosta. "Science and the Military." Bulletin of the Atomic Scientists 33, January 1977: 10-11.

Introduction to a new series of articles on military research and development.

Turner, G. L'E., ed. The Patronage of Science in the Nineteenth Century. (NOORDHOFF, Leyden, The Netherlands, 1976.)

Three of the five essays in this volume examine the patronage of science in specific locales: Robert Fox focusses on "the scientific enterprise and the patronage of research in France, 1800-70"; J.B. Morrell explores "the patronage of mid-Victorian science in the University of Edinburgh"; and D.S.L. Cardwell looks at "the patronage of science in nineteenth-century Manchester." The fourth essay, by R.M. MacLeod, is a detailed investigation of the efforts of the Treasury to support science, while the final article, by W.H. Brock, is an overview of the various public and private sources drawn upon by Victorian scientists.

Von Hippel, Frank. "Looking Back on the Rasmussen Report." Bulletin of the Atomic Scientists 33, February 1977: 42-47.

The politics of the controversial 1974 reactor safety study.

Wade, Nicholas. "Dicing with Nature: Three Narrow Escapes." Science 195, 28 January 1977: 378.

A description of three potentially dangerous experiments employing the recombinant DNA technique, and the actions of the scientists responsible: one destroyed the "bug" created, another asked for a safety agreement from the recipients of his viruses, and the third decided not to carry out the work at all.

Wade, Nicholas. "Gene-Splicing: At Grass-Roots Level a Hundred Flowers Bloom." Science 195, 11 February 1977: 558-560.

The recombinant DNA method of gene-splicing has evoked a considerable amount of public interest and debate. This article reviews recent actions by several state legislatures, by industry, and by environmental groups.

Wade, Nicholas. "Gene-Splicing: Cambridge Citizens OK Research but Want More Safety." Science 195, 21 January 1977: 268-269.

An overview of the dispute in Cambridge, Massachusetts about plans to conduct two of the more hazardous categories of recombinant DNA research.

Wade, Nicholas. "Gene-Splicing: Critics of Research Get More Brickbats than Bouquets." Science 195, 4 February 1977: 466-469.

This article looks at the reactions within the scientific community to scientists who have been openly critical of recombinant DNA research.

Wallace, Bruce. "The Cost of Basic Research." Bio Science 27, February 1977: 83.

An editorial criticizing demands that research yield results on a dollar-for-dollar basis.

Webster, Charles. The Great Instauration. Science, Medicine and Reform, 1626-1660. New York: Holmes and Meier, 1976.

Webster uses seventeenth century England as a laboratory for examining the relationship between social values and scientific concepts. The focus is on the intellectual environment which gave rise to certain kinds of scientific activities. (See the review by Robert G. Frank, Jr. in Science 195, 28 January 1977: 385-386.)

Weinberg, Alvin M. "The Many Dimensions of Scientific Responsibility." Bulletin of the Atomic Scientists 32, November 1976: 21-24.

A discussion of various dimensions of the scientist's social responsibility: publicizing the faults of technologies; working to correct those faults; responsibility when speaking to the public; and delineating the line between scientific knowledge and scientific ignorance. For the last, Weinberg introduces the term "transcientific" to refer to "those questions that are epistemologically matters of fact, but for various reasons are beyond the capacity of science to answer."

Whitley, Richard. "Umbrella and Polytheistic Scientific Disciplines and Their Elites." Social Studies of Science 6, September 1976: 471-498.

Examining "disciplines" instead of invisible colleges, the author compares the inner workings of homogeneous disciplines with the workings of highly differentiated disciplines. Among differential disciplines, he distinguishes between "umbrella" disciplines, where differences are between special ties or research areas, and "polytheistic" disciplines, where differences are between metaphysical commitments.

Whyte, Lancelot Law. The Universe of Experience. New York: Charles Scribner's Sons, 1976.

Reviewed by Alexander Langsdorf, "Beyond Science and Religion," Bulletin of the Atomic Scientists 32, November 1976: 47: "It is a summing up of a 76-year lifetime of experience which was gained cantering 'around the no-man's-land of science along the frontiers where physics, biology, and psychology face the unknown, with an eye also on philosophy.' The book is an effort to present 'a world view beyond science and religion,' emphasizing concepts of form and unity throughout the universe."

York, Herbert F., and G. Allen Greb. "Military Research and Development: A Postwar History." Bulletin of the Atomic Scientists 33, January 1977: 12-27.

An account of the evolution of the scope and structure of military R&D in the U.S. over the past thirty years, and of the crises which have given it its

present dimension.

Zwerdling, Daniel. "Chemical Catastrophes." The Progressive 41, February 1977: 15-19.

Noting the current PCB controversy, the author continues: "The PCB revelation, disturbing enough on its own, was just one more barrage of warnings that the nation's chemical culture is going out of control....Society treats these chemical incidents as isolated accidents because accidents have easy explanations and solutions. But this national mind-set obscures the most dangerous threat to the nation's health -- the inevitable, long-term chronic threat from a chemical technology which has become part of the social fabric.... Protecting the public from the chemical threat would mean banning or sharply restricting thousands of chemicals, entire classes of chemicals -- and that means basically altering the social and economic system which breeds the chemical culture and guarantees that toxins will accumulate and poison us in our water, food, air and bodies."